SPECIFICATIONS

FOR

TRIPLE-EXPANSION

TWIN-SCREW PROPELLING ENGINES,

WITH BOILERS AND AUXILIARY MACHINERY,

FOR

Cruisers Nos. 7 and 8.

Cincinnati & Raleigh,

EACH OF ABOUT 3,000 TONS DISPLACEMENT.

BUREAU OF STEAM ENGINEERING,
NAVY DEPARTMENT,
WASHINGTON, D. C.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
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LIST OF PLANS ACCOMPANYING THESE SPECIFICATIONS.

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SPECIFICATIONS

FOR

Vertical Twin-Screw Triple-Expansion Engines,

WITH

BOILERS AND AUXILIARY MACHINERY,

FOR

Cruisers Nos. 7 and 8.

EACH OF ABOUT 3,000 TONS DISPLACEMENT.

REFERENCE BEING HAD TO THE DRAWINGS ACCOMPANYING AND FORMING PART OF THESE SPECIFICATIONS.

GENERAL DESCRIPTION.

The propelling engines will be rights and lefts, placed in water-tight compartments and separated by a fore-and-aft bulkhead. These engines will be of the vertical, inverted-cylinder, direct-acting, triple-expansion type, each with a high-pressure cylinder 36 inches, an intermediate-pressure cylinder 53 inches, and two low-pressure cylinders each 57 inches in diameter; the stroke of all pistons being 33 inches. The collective indicated horse-power of propelling, air-pump, and circulating-pump engines will be 10,000 when the main en-

gines are making about 164 revolutions per minute. All lower cylinder-heads of the main engines will be steam-jacketed. The high-pressure cylinder of each engine will be forward and the low-pressure cylinders aft. The main valves will be of the piston type, worked by Stephenson link-motions with double-bar links. The piston-valves, valve-liners, and valve-gear will be made interchangeable, as hereinafter specified. There will be one piston-valve for each high-pressure cylinder, two for each intermediate-pressure cylinder, and two for each low-pressure cylinder. Each main piston will have one piston-rod, with a cross-head working between guides. The framing of the engines will consist of cast-steel inverted Y-frames, trussed by wrought-steel stays. The engine bed-plates will be of cast-steel, supported on wrought-steel keelson-plates built in the vessel. The crank-shafts will be made in two short interchangeable sections and one long section. All shafting will be hollow. The shafts, piston-rods, connecting-rods, and working parts generally will be forged of mild open-hearth steel.

The condensers will be made entirely of composition and sheet-brass. Each condenser will have a cooling surface of about 7,000 square feet, measured on the outside of the tubes, the water passing through the tubes. For each propelling engine there will be a double, vertical, single-acting air-pump worked by a vertical compound engine. The circulating pumps will be of the centrifugal type, one for each condenser, worked independently. The propellers will be three-bladed, right and left, of manganese bronze, or approved equivalent metal.

Each engine-room will have an auxiliary condenser of sufficient capacity for one-half the auxiliary machinery, each condenser being connected with all the auxiliary machinery.

Each of these condensers will have a combined air and circulating-pump.

There will be four double-ended boilers, and two single-ended boilers to be used as auxiliaries, placed in four watertight compartments as shown. Two of the main boilers will

be about 13 feet 4 inches outside diameter and 20 feet 3½ inches long, the other two main boilers will be about 14 feet 6½ inches outside diameter and 20 feet 3½ inches long. The two auxiliary boilers will be about 11 feet 2 inches outside diameter and 9 feet ½ inch long.

They will be constructed for a working pressure of 160 pounds per square inch.

Each of the main boilers of 13 feet 4 inches outside diameter will have 6 corrugated furnace-flues 3 feet 4 inches internal diameter. Each of the main boilers of 14 feet 6½ inches outside diameter will have 6 corrugated furnace-flues 3 feet 8 inches internal diameter. Each of the auxiliary boilers will have two corrugated furnaces of 2 feet 9 inches internal diameter.

The total heating surface will be about 19,382 square feet, measuring the tubes on the outer surface, and the grate surface 597 square feet. There will be a main feed-pump in each of the forward and after fire-rooms, and an auxiliary feed-pump in each of the engine rooms, and a small pump for each auxiliary boiler. Each of the feed-pumps will connect with a main feed-pipe, each pump having a capacity sufficient to supply the four main boilers when steaming at full power. There will be two smoke-pipes located as shown.

The forced-draft system in each fire-room will consist of one blower, which will discharge into a main air-duct under the fire-room floors, from which a branch duct will lead to the ash-pit of each furnace. Means will be provided for closing the ash-pits when under forced draft and for preventing leakage of gases out of the furnace-doors. The draft to each furnace will be regulated by means of a damper.

There will be steam reversing-gear, ash-hoists, turning-engines, auxiliary pumps, engine-room ventilating-fans, for driving workshop machinery, a distilling apparatus, and such other auxiliary or supplementary machinery, tools, instruments, or apparatus as are described in the following detailed specifications or shown in the accompanying drawings.

CYLINDERS.

They will consist of casings of best quality of cast-iron, with working-linings for the high-pressure cylinders and all the valve-chests. The cylinder casings will include the valve-chests, steam-ports and passages, the lower heads, and the various brackets to which the cylinder-supports will be attached. The steam and exhaust-ports will be smoothly cored to the dimensions shown in drawings, the walls of the passages being strongly stayed by ribs, and if necessary by screwed stay-bolts with ends riveted over.

The flanges for securing the cylinders to each other will be so faced that when bolted together the centers of the high-pressure and intermediate-pressure cylinders will be 7 feet 5½ inches apart, the centers of the intermediate and first low-pressure cylinder will be 7 feet 9 inches apart, and the centers of the low-pressure cylinders will be 5 feet 6 inches apart, with the cylinder-axes all in one plane and parallel. The cylinder casings will be bolted together and to their frames by body-bound steel bolts. They will be bored to their respective diameters when in a vertical position.

HIGH-PRESSURE CYLINDER CASINGS.

The head will be cast with double walls and the barrel will be 1¼ inches thick. It will be faced and bored, as shown, for the reception of the working cylinder-lining and for the valve-chest linings. The brackets at the bottom for attachment of the supporting frames will be well ribbed and truly faced for the frames. There will be flanges for bolting to the intermediate cylinder, these being faced to a plane parallel to the axis of the cylinder. The walls of the steam passages will be properly stayed. There will be facings, flanged and ribbed where necessary, for the attachment of the cylinder and valve-chest covers, steam-pipe, exhaust-pipe, piston-rod stuffing-box, relief-valves, drain-cocks, indicator-pipes, jacket steam and drain-pipes, oil-cups, starting-valve pipes, and starting-valve chests, and such facings as may be required for the reversing-gear. There will be a hand-hole in the cylinder-head, as shown.

INTERMEDIATE CYLINDER CASINGS.

They will be of close-grained cast-iron as hard as can be properly worked. They will have no cylinder-liners. Each will have two piston-valves. Each will have faced flanges for bolting to the high and low-pressure cylinders. There will be hand-holes as shown in the cylinder-heads. The barrels of the casings will be $1\frac{3}{8}$ inches thick. There will be brackets well ribbed and truly faced for the supporting frames, also facings for steam and exhaust-pipes, receiver safety-valves, receiver live steam-pipes, starting-valve pipes, starting-valve chests, piston-rod stuffing-boxes, hand-hole covers, drain-cocks, indicator-cocks, jacket steam and drain-pipes, oil-cups, and such facings as may be required for the reversing-gear. There will also be faced flanges for bolting the high-pressure and intermediate-pressure cylinders together.

LOW-PRESSURE CYLINDER CASINGS.

Each will be of the same material as the intermediate-pressure casing and will be similarly fitted, with the following exceptions: each forward low pressure-cylinder casing will have two faced brackets, one for bolting to the intermediate-pressure cylinder and one for bolting to the after low-pressure cylinder. The after low-pressure cylinder will have one faced bracket for attachment to the forward low-pressure cylinder. There will be facings for man-hole covers, and auxiliary exhaust-pipes.

The steam-pipe connecting the two low-pressure cylinders will have a butterfly throttle-valve.

HIGH-PRESSURE CYLINDER LININGS.

They will be of close-grained cast-iron as hard as can be properly worked, turned and faced to fit the cylinder casings. Each lining will have a bearing at about the middle of its length.

The linings will be secured to the casings by round-headed counterbored steel bolts, placed radially around the cylinder

counterbore with convenient spacing. The linings will be counterbored to receive the bolt-heads, the nuts being on the outside of the casings.

The linings, after being secured in place in the casings, will be smoothly and accurately bored to a diameter of 36 inches and to a thickness of $1\frac{1}{4}$ inches, the boring to be done with the cylinders in a vertical position. The linings will be counterbored at lower ends, leaving the working bores $34\frac{1}{8}$ inches long.

CYLINDER COVERS.

They will be of the same quality of cast-iron as the high-pressure cylinder casings, and cast with double walls, 1 inch thick, well stiffened by ribs of the same thickness, each cover with a 15-inch man-hole. They will be so formed as to leave as little clearance as practicable.

Pockets will be cored for the heads of the piston-follower bolts. Each cover will be turned and faced to fit its cylinder casing, bored and faced at man-hole, finished on outside of flanges, and rough-finished elsewhere on outside.

The cover of the high-pressure cylinder will be secured to the cylinder casing by thirty-two $1\frac{3}{8}$-inch steel studs, the cover of the intermediate by thirty-six $1\frac{3}{8}$-inch steel studs, and each low-pressure cover by thirty-two $1\frac{1}{4}$-inch steel studs.

Holes will be drilled and tapped for jack-bolts and eye-bolts.

CYLINDER MAN-HOLE COVERS.

They will be of cast-iron or cast-steel, those in the upper covers cored for clearance of piston-rod nuts, turned and faced to fit man-holes, and finished on the outside of flanges. They will be secured by $1\frac{1}{8}$-inch steel studs, spaced as shown in the drawings, and will have holes drilled and tapped for jack-bolts.

The man-hole cover on low-pressure cylinder-head will be 11 inches by 14 inches, secured to head by eight 1-inch bolts

CYLINDER CLEARANCES.

Care will be taken that the clearances in the cylinders are made no larger than absolutely necessary. After the engines are set up in place and connected, the volume of the clearance at each end of each cylinder will be carefully measured by filling the space with water or oil, and the result plainly marked on some conspicuous part of the cylinder's casing. Marks will also be made on the cross-head guides showing the position of the pistons where the clearances were measured.

STEAM-JACKETS.

The cylinders will be steam-jacketed on bottom.

All ribs must be cored out so as to allow a free circulation of the jacket-steam and a free drainage of the water of condensation.

Steam for the jackets will be taken from the main steam-pipe in each engine-room, on the boiler side of the engine stop-valve, and will lead to the head of the high-pressure cylinder. A branch, with an adjustable-spring reducing-valve, adapted to a pressure of from 30 to 80 pounds, will lead to the intermediate-pressure cylinder-head.

Another branch, with an adjustable-spring reducing-valve, adapted to a pressure of from 0 to 30 pounds, will lead to the low-pressure cylinder-heads.

Each branch steam-pipe will have a stop-valve close to the cylinder-head.

There will be on the intermediate jacket steam-pipe, on the jacket side of the reducing-valve, an adjustable-spring safety-valve, adapted to the same pressures as the reducing-valve, and on the low-pressure jacket steam-pipe a similar valve, adapted to the jacket pressure.

A 1-inch brass drain-pipe will pass through a hole in the lowest part of the wall of each cylinder-head. This drain-pipe will lead to an approved automatic trap with blow-through and by-pass pipes and valves, thence to the lower part of the feed-tank, with a branch to the bilge. Each draw-

pipe will have a stop-valve close to its jacket. The drainage of the head of each cylinder will be entirely independent as far as the trap-discharge, from which point the drains may be in common. All pipes in the drain system will be put together by union joints so as to be easily overhauled.

VALVE-CHESTS.

The valve-chests of each high-pressure cylinder will be fitted for one piston-valve, each intermediate-pressure for two, and each low-pressure for two.

There will be openings at each end for inserting and removing the valves and working-linings. The chests will be accurately bored and faced for the reception of the working-linings.

Before the insertion of the linings the steam and exhaust passages must be thoroughly cleaned out, and care taken that the passages are nowhere contracted to less than the specified areas.

Each intermediate and low-pressure valve-chest will have a 3-inch adjustable-spring safety-valve of approved pattern.

All valve-chests will also be fitted with suitable composition drain-cocks or valves that may be operated from the working-platform, the valves to discharge through pipes into the bilge and feed-tanks with the necessary valves for directing the water to either.

VALVE-CHEST LININGS.

There will be a working-lining at each end of each valve-chest for each piston-valve. They will be of cast-steel or close-grained cast-iron as hard as can be properly worked, accurately turned and faced to fit the casings, and accurately bored to an internal diameter of 20 inches, leaving the walls 1 inch thick.

They will be forced into place, making all joints perfectly tight, and secured by screws tapped half into the linings and half into the casings.

The following valve-chest linings are interchangeable:

The upper linings of the high and intermediate-pressure cylinders;

The lower linings of the high and intermediate-pressure cylinders;

The upper linings of the low-pressure cylinders;

The lower linings of the low-pressure cylinders.

The steam-ports at the top of the high and intermediate-pressure cylinders will be $3\frac{3}{16}$ inches wide, those at the top of the low-pressure cylinders will be $3\frac{5}{8}$ inches wide.

The steam-ports at the bottom of all cylinders will be $3\frac{5}{16}$ inches wide.

The steam-ports will have alternating right and left diagonal bridges, taking up not more than one-quarter of the total port area.

The edges of all ports will be finished to a uniform outline.

VALVE-CHEST COVERS.

They will be made of cast-steel, in dished form. All will be ribbed.

The flanges will be turned and faced to fit the openings in valve-chests. The covers will be finished on the outside. Each lower cover will be faced and bored to receive the valve-stem stuffing-boxes. Each upper cover will be bored to receive the balancing-pistons, as shown.

All covers will be extended on the inside, as shown, to prevent the valves over-riding the liners when disconnected.

There will be approved provision for proper oiling of the valve-stems. Each upper cover will have a smaller finished cast-steel cover, flanged and bolted on, over the upper end of the valve-stem.

The lower covers will have the necessary faces for securing the valve-stem crosshead-guides.

The upper cover of each valve-chest will have a cylinder cast on, bored out to 5 inches in diameter for the high and intermediate-pressure cylinders, and $8\frac{1}{2}$ inches in diameter for the low-pressure cylinders. In these cylinders will work the balancing-pistons of the valves, with the steam on the under side of the piston. On the upper side of the high-pressure

[redacted]

cast steel—

2 —

of the high pressure valves will be of cast iron or cast steel, and those of the intermediate pressure and [redacted] valves

balancing-piston there will be a connection with the intermediate-pressure receiver. The intermediate-pressure and low-pressure balancing-cylinders will have a similar connection with the condenser. The balancing-piston will be of composition with cast-iron packing-rings.

Each valve-chest cover will be secured by sixteen $1\frac{1}{8}$-inch steel studs, with finished wrought-iron nuts.

The valve-chest cover will be interchangeable as follows:

The top covers of high-pressure and intermediate-pressure valves;

The top covers of the low-pressure valves;

The bottom covers of the intermediate-pressure and low-pressure valves.

Although the bottom covers of the high-pressure and other valves are not mutually interchangeable, the high-pressure can be substituted for any of the others.

PISTON-VALVES.

All the piston-valves will be made in two parts. The high-pressure valves will be of cast-iron of a general thickness of 1 inch; all the intermediate and low-pressure piston-valves will be of composition, with a general thickness of $\frac{3}{8}$ inch. Each of these parts will consist of a hollow piston, with follower, wearing-ring, and two packing-rings.

The high and intermediate-pressure valves will be exactly alike, excepting the difference of thickness on account of their being made of different metals.

The packing-rings of all the main-engine valves are interchangeable.

The upper and lower heads of each of the piston-valves are interchangeable.

The followers will be of composition, secured in place by steel through-bolts with wrought-iron nuts and brass split-pins. The follower-bolts will pass through lugs on the inside of the valve-shell and have their heads so formed and fitted

[redacted]

excepting those of the H.P. valves -

The H.P. valve stem takes hold,
directly of the cross block

as to prevent turning. The wearing-rings will be of cast-iron, finished to a neat end fit between the valve-body and follower, but to a loose side fit. They will be smoothly and accurately turned and faced for the reception of the packing-rings. The packing-rings will be of the best tool-steel, turned larger than the bore of valve-seat, cut obliquely, tongued and sprung into place. The rings will be $\frac{7}{8}$ inch on the face.

The two parts of each valve will be separated, when in place on their valve-stem, by a cast-steel distance-piece, which will be of such length as to make the steam and exhaust laps as follows:

Steam lap for all valves—top, $2\frac{7}{16}$ inches; bottom, $2\frac{1}{16}$ inches.

Exhaust lap for high-pressure and intermediate-pressure valves—top, 0; bottom, $\frac{7}{8}$ inch.

Exhaust lap for low-pressure valves—top, $\frac{15}{16}$ inch; bottom, $1\frac{5}{32}$ inches.

VALVE-STEMS.

They will be of forged-steel, $2\frac{3}{4}$ inches in diameter at the stuffing-boxes and reduced to $1\frac{3}{4}$ inches where they pass through the valves. The lower end of each stem will have a thread cut on it and be fitted with two steel nuts for securing it to the cross-head. A slot will be cut in the thread on each stem and fitted to a feather in the cross-head. The nuts will have collars recessed in counterbores in the cross-heads and secured by set-screws. The thread on each stem must be sufficiently long to allow a reasonable latitude of adjustment. The top of each stem will be finished with a $1\frac{1}{2}$-inch right-hand thread and a 1-inch left-hand thread. The $1\frac{1}{2}$-inch thread will be fitted with a cast-steel balancing-piston, acting as nut and bearing against the top of the valve. The 1-inch thread will be fitted with a nut to lock the balancing-piston in place.

A split-pin will be put through the valve-stem to keep the 1-inch nut from coming off.

The intermediate and low-pressure valve-stems will be interchangeable.

CYLINDER RELIEF-VALVES.

There will be a 3½-inch adjustable-spring relief-valve on each end of each main cylinder. The valves and their casings will be of composition. Pipes will lead from the relief-valves to the bilge with easily-broken joints.

These valves will have nickel seats or their equivalent, and the valve-fittings will be so constructed that the valves can be easily overhauled without slacking the springs and so that steam will not come into contact with the springs. The springs will have approved means of adjustment, and will be long enough to allow the valves to open to their full extent without unduly increasing the load. The valves will be guided by loosely-fitting wings. The springs will bear on shoulders on spindles which fit loosely in sockets recessed in the backs of the valves. These spindles will be so fitted that the valves can be moved by the application of a lever. The valves will be fitted with casings, which will prevent danger of people being scalded by hot water from the cylinders. Suitable fulcrums will be on casings for the application of levers for working the valves; one lever to be furnished for each engine-room. All springs must pass a satisfactory test.

The spring-casing of each valve will be fitted with a suitable lock; all locks to have similar keys.

CYLINDER DRAIN-COCKS.

Each cylinder will be fitted with a 2-inch packed drain-cock, placed so as to drain the cylinder thoroughly. The cocks must be perfectly tight without undue friction. The drain-cock of each cylinder of each engine will be worked by a single lever at the working-platform. All the drain-cocks of each engine will discharge into a pipe leading to the fresh-water side of the condenser, with a branch to the bilge. This pipe will have a stop-valve near the condenser, and will have a spring non-return valve, without hand-gear, which can open to the bilge-discharge when the drain to condenser is closed, but which will prevent air entering the condenser at any time. Small drain-cocks will be fitted to the lowest parts of drain-pipes.

cylinder by a 2-inch copper pipe. These valves will all exhaust into a 2-inch pipe leading to the condenser, the branch from each valve having a stop-valve close to the valve-chest. Each steam-port of each starting-valve will have an area of about 3 square inches. Each starting-valve will be worked by a lever at the working-platform; these levers to be placed in the same order as their respective valves, and, if vertical, will be arranged to move away from the working-platform when piston moves up; if horizontal, they will move in the same direction as the desired motion of the piston. The valves are to be in middle position when their levers are vertical or horizontal.

PISTON-ROD STUFFING-BOXES.

They will be made of composition, and fitted with approved metallic packing with efficient means of lubrication. The packing of each stuffing-box will be made in two independent sections, so that in case of injury to one section the other alone will make a tight joint; this packing to be in all respects equal to Watson's.

VALVE-STEM STUFFING-BOXES.

They will be similar to the piston-rod stuffing-boxes.

PISTONS.

They will be of cast-steel or approved bronze, and will be dished.

The followers, made as shown in the drawings, will be of cast or forged-steel, secured in place by $1\frac{1}{4}$-inch bolts, 12 for each high, 16 for each intermediate, and 16 for each low-pressure piston.

The follower-bolts will be steel studs, screwed into the pistons; the bodies of the studs to be square, passing through square holes in the followers. The follower-bolt nuts will be of wrought-iron, finished and case-hardened, each nut to be secured in place by a brass split-pin of ample size.

Each piston will have two packing-rings, each $\frac{5}{8}$ inch wide and $\frac{3}{4}$ inch thick, of hard cast-iron, cut obliquely and tongued.

The packing-rings will be set out by steel springs of ap-

proved pattern, all set to an equal and proper tension. There will be sufficient clearance between the piston and cylinder to allow for difference of expansion.

Each packing-spring must be so secured in the piston as to be firmly held in place and easily inserted and removed. Th springs must be of best spring-steel, properly tempered.

When completed the pistons must be carefully weighed, and no excess of weight will be allowed over that due to the dimensions shown in the drawings.

PISTON-RODS.

The piston-rods will be of forged-steel, $6\frac{7}{8}$ inches diameter, excepting at ends, where they will be $5\frac{3}{4}$ inches diameter over threads. They will be turned to fit the pistons, with collars, as shown, and fitted each with a composition nut at the piston end secured by a screwed stop-pin. The nut at the cross-head end will be secured by a set-screw. The parallel parts will be smoothly and accurately turned.

Each piston-rod will have, at its seating in the piston, a collar $8\frac{1}{2}$ inches diameter and $1\frac{1}{4}$ inches thick, well filleted, and recessed in the piston as shown.

They will be kept from turning in the pistons and cross-heads by stop-pins.

CROSS-HEADS AND GIBS, AND BRASSES.

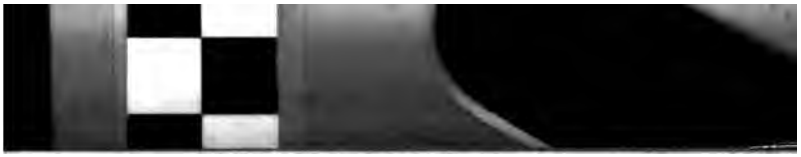
The cross-heads will be of cast-steel. The cross-head pins will be 8 inches in diameter and $8\frac{3}{4}$ inches long, and will be conically cored.

The gibs will be prevented from moving up or down on the cross-heads by lips, and will be firmly held to the cross-heads by bolts passing through the shoes and tapped into the gibs.

The gibs will be of composition lined with white-metal. Their bearing surface will be 21 inches long and 18 inches wide.

CONNECTING-RODS.

The connecting-rods, with their caps and bolts, will be of forged-steel, finished all over.



They will be 66 inches long between centers, turned 7 inches in diameter at small end and 9½ inches at large end, the sides being faced off to a uniform thickness of 7 inches.

The cross-head end of each rod will be forked to span the cross-head pins. The brasses will be bored to 8 inches diameter to fit pins. Each of the caps will be secured by two 3¼-inch bolts.

The crank-pin end of each connecting-rod will be increased in thickness to 13½ inches, faced on each side, and bored 18½ inches in diameter for the brasses. The caps will be 4½ inches thick at the crown, each to conform to the shape of the connecting-rod end. The bolts will be 4¼ inches in diameter; the heads to be fitted with stop-pins and the upper ends of bolts to be provided with split-pins of ample size outside the nuts. The nuts will be of wrought-iron, each with a collar recessed into the connecting-rod head and secured by a set-screw. The cap-bolts will pass partly through the crank-pin brasses and will be fitted with set-screws for holding their weight when backing off the nuts.

In each jaw and each cap of each connecting-rod, two 1⅜-inch bolts will be fitted, passing through the metal of the rods and caps, and tapped into the corresponding lip of the crank-pin brasses to prevent closing-in when heated, each of these bolts being secured by a set-screw.

Composition distance-pieces will be fitted between the connecting-rods and caps; they will be so fitted as to be removable without taking out the cap-bolts, and will be channeled so as to be easily reduced when taking up lost motion.

The caps will each be fitted with two eye-bolts for handling.

CRANK-PIN BRASSES.

They will be accurately fitted to the connecting-rods and secured as before specified. They will be fitted with approved white-metal in strips, accurately fitted to the crank-pins, and properly fitted for distribution of oil. They will be 2 inches thick, including white-metal, and faced with sufficient clearance between crank-webs to prevent nipping when heated.

ENGINE-FRAMES.

Each cylinder will be supported by two cast-steel inverted Y-frames, as shown in the drawings. The upper foot of each frame will be $1\frac{3}{4}$ inches thick and will be secured to its cylinder by eight $1\frac{3}{4}$-inch body-bound bolts.

Each lower foot of the frames is $1\frac{1}{2}$ inches thick, and is secured to the bed-plate by six $1\frac{1}{2}$-inch body-bound bolts.

All the feet of the frames will be faced to fit the planed faces provided for them on the cylinders and the bed-plates.

Each frame, on the backing-side, will be faced to act as guide for its cross-head. Each frame, on the go-ahead side, will be faced to receive a cast-iron wearing-guide for cross-head. Facings will also be provided for reversing-gear, as may be required.

The frames under each cylinder will be ~~tied~~ to each other by two $1\frac{1}{16}$-inch tie-rods, swelled to 2 inches outside diameter of threads at ends.

BED-PLATES.

They will consist, each, of three steel castings, flanged and bolted together, as shown.

The upper and lower flanges will be connected and properly stiffened by ribs, as shown.

The bed-plates will be secured to the engine-seatings by $1\frac{3}{8}$-inch bolts through the lower flange, and by twelve of the frame-bolts, as shown in drawing, and they will be properly finished and faced for crank-shaft brasses and caps and for the flanges of the supporting columns. Each jaw will be fitted with an adjustable composition chock for the vertical alignment of the shaft. The bed-plates will have facings for the reversing and turning-engines, as may be required.

CRANK-SHAFT BRASSES AND CAPS.

The brasses for each bearing will be cylindrical, in two parts, lined with approved white-metal, fitted with ample oil-channels, faced $17\frac{7}{8}$ inches long for the high and intermediate-pressure

journals, and 17⅜ inches for the low-pressure journals, turned to fit cap and chock, as shown, and accurately bored to fit the journals of shaft. The chock will be of composition. Provision will be made for circulating water around or through the butt brasses. The caps will be of cast-steel, 3¾ inches thick and 13 inches wide, with lips to match the jaws. Each cap and upper brass will have an oval hand-hole for the purpose of feeling the journal. This hand-hole will have a cover, with handle—the lower part of the cover being formed into a perforated tallow-box, reaching to within a quarter of an inch of the journal.

The cap-bolts will be of forged-steel, 3½ inches in diameter, each provided with a collar, as shown. One end of each bolt will be threaded and screwed into the engine bed-plate. The other end will be threaded and fitted with finished wrought-iron collar-nut and set-screw—the part beyond the nuts will be squared and each fitted with a split-pin.

The caps and brasses will be tapped and fitted with eye-bolts for handling.

The brasses will be separated by channeled brass distance-pieces, which will extend over the offset in the pillow-blocks to keep the brasses from turning.

After the engines are secured in the vessel the brasses will be bored out in place to perfect alignment, if required. They will also be tried on their shafts and any defects made good by scraping to a proper bearing.

The brasses will be so fitted that the only bearing of the journals will be on the surface of the white-metal.

CROSS-HEAD GUIDES.

A planed surface on the inverted Y-frame will answer as a guide when backing. The guide to take the thrust when going ahead will be of cast-iron. It will be bolted to the inverted Y-frame, and the frame and guide will be so constructed and joined that there will be a water-passage to keep the guide cool.

The guides will be smoothly and accurately finished, and will be fitted in place to proper alignment. Brass oil-boxes will be screwed to both ends of guides.

VALVE-GEAR.

It will be of the Stephenson type, with double bar-links. All valves will be worked direct. There will be one cross-head for the intermediate-pressure valve-stems and one cross-head for the low-pressure valve-stems of each engine.

The valve-gear will be so adjusted that the mean cut-off in full gear for both ends of each cylinder will be at 0.7 stroke.

ECCENTRICS.

They will be of cast-steel, each in two parts.

The two parts of each eccentric will be neatly fitted together and secured by two steel bolts. They will be bored out to a snug fit on the shafts and turned accurately on the outside to an eccentricity of $4\frac{3}{16}$ inches, and will be recessed at each side for the flanges of the eccentric-straps. Each backing eccentric will be securely keyed on the shaft, and each forward motion eccentric will be secured to the corresponding backing eccentric by through-bolts in slotted holes, the holes to be filled up after the eccentrics are set.

The eccentrics will be interchangeable, as follows: the high-pressure with the after low-pressure, and the intermediate-pressure with the forward low-pressure.

ECCENTRIC-STRAPS.

They will be of composition, finished all over, made with flanges to fit the recesses of eccentrics and with lugs for the clamping-bolts and for the eccentric-rods. The two parts of each strap will be held together by two steel bolts with finished heads, lock-nuts, and split-pins, and fitted with channeled brass distance-pieces. Each strap will be accurately and smoothly bored to fit the eccentrics both on face and recesses, and properly channeled for oil. All straps will be interchangeable.

ECCENTRIC-RODS.

They will be of forged-steel, finished all over. Each rod will have a T-head secured to its eccentric-strap by two steel stud-bolts with nuts locked in place.

The upper end of each rod will be forked to span the link and fitted with brasses with adjustable wedge-blocks, which will be interchangeable for all the rods.

The two brasses in the forks of each rod must be fitted accurately in line with each other and smoothly bored to fit the link-pins.

All go-ahead rods will be interchangeable and all backing rods will be interchangeable.

MAIN-LINKS.

They will be of double-bar pattern, of forged-steel, finished all over.

They will all have the pins for eccentric-rods forged on and finished to not less than 24 inches between centers. Extensions of the pins at one end of each link will form the pins for suspension-rods. Each pair of bars will be secured together by through-bolts, and thimbles fitted with finished steel-nuts well secured with split-pins.

All the links will be interchangeable.

LINK-BLOCKS.

They will be of forged-steel, finished all over. The blocks will be forged with link-block pins.

They will terminate at each end in a pair of jaws to span the corresponding bar on the link. These jaws will be fitted with composition gibs, finished to the curve of the links, the upper gib in each jaw being fitted with a key with screw adjustment.

SUSPENSION-LINKS.

Each Stephenson link will be suspended from the corresponding arm of the reversing-shaft by two flat-sided, forged-steel suspension-links.

to receive the valve - stem
Sleeve as heretofore specified

The ends of these links will be fitted with composition bushings, bored to fit suspension-pins on main links and pins on reversing-shaft arms.

The suspension-links will be interchangeable throughout.

VALVE-STEM CROSS-HEADS AND GUIDES.

The intermediate-pressure and low-pressure valve-stems will have cast-steel cross-heads, the cross-heads taking hold of the link-blocks directly. The boss of each arm of each cross-head will be bored to fit the lower end of valve-stems and will have a key-way for securing to valve-stem. The cross-head guides will be cast-steel brackets bolted to the valve-chest covers. The high-pressure valve-stem will take hold of the link-block directly. The high-pressure stem will be guided by a bracket made in two parts, bolted to the valve-chest cover. All the valve-stem cross-heads of the intermediate and low-pressure cylinders will be interchangeable.

REVERSING-GEAR.

The reversing-gear for each engine will consist of a steam cylinder and a hydraulic controlling cylinder placed vertically and acting directly on an arm fixed on the reversing-shaft. Each will be placed on the side of its engine, between the intermediate-pressure and low-pressure cylinders, and secured to engine-frames and bed. The steam piston-rod will be secured to a steel cross-head, working in suitable guides, and connecting with the arm on the reversing-shaft. The piston-rod will pass through the controlling cylinder with uniform diameter. The controlling cylinder will be of composition. The valve of the steam cylinder will be of the piston pattern, of composition, working in a composition-lined valve-chest. There will be a by-pass valve on the hydraulic cylinder, which will be worked by a continuation of the stem of the steam piston-valve. These valves will be worked by a system of differential levers, the primary motion being derived from the hand-lever on the working-platform and the secondary

motion from a pin on the reversing-arm, all parts being so adjusted that the reversing-engine shall follow the motion of the hand-lever and be firmly held when stopped. There will be a stop-cock in the by-pass pipe of the hydraulic cylinder, and a pump for reversing by hand will be connected to the hydraulic cylinder, with its lever convenient to the working-platform. The by-pass pipes will pass through the valve-box of the hand-pump in such a way as to leave the hand arrangement always in gear. The piston of the hydraulic cylinder will be packed by two cup-leathers. Steam for the reversing-engine will be taken from the auxiliary steam-pipe.

REVERSING-SHAFTS.

There will be one forged-steel reversing-shaft for each engine. It will have five arms, one connecting with the reversing-engine and one with each link. The shaft will be supported by suitable bearings. Each reversing-arm will be made with a slot, fitted with a composition block, to which the suspension-rods will be attached. Each block will be adjustable in the slot of its arm by a screw and hand-wheel with approved locking device, and will be fitted by a suitable index. The slots in these arms will be so arranged that the links may always be thrown into full backward gear irrespective of the position of the block in the slot; and the length of the slots will be such that the cut-off may be varied from 0.5 to 0.7 of the stroke. All the arms will be neatly fitted and keyed to the shafts.

REVERSING-SHAFT BEARINGS.

They will be made of cast-steel, with bottom brasses and composition caps, and will be securely bolted to their supports. They will be bored to fit the journals of the shafts.

The caps will be secured by bolts fitted with lock-nuts.

EXHAUST-PIPES.

A 14½-inch pipe will lead from the exhaust side of each high-pressure valve-chest, with a 16-inch branch to each end of the valve-chest of the corresponding intermediate cylinder.

A 20-inch pipe will lead from the exhaust side of each intermediate valve-chest, with a 16-inch branch to each end of the valve-chest of each of the two corresponding low-pressure cylinders.

Each low-pressure cylinder will have a 20-inch exhaust-nozzle. A 20-inch pipe will lead from the forward low-pressure cylinder to a T-nozzle on the after low-pressure cylinder. This T-nozzle will connect with a 28-inch pipe leading to the condenser of its engine, and will have in it a 28-inch straight-way-valve.

WORKING-PLATFORMS.

The floors on the outboard side of each main engine, near the high-pressure cylinder, will be conveniently arranged to serve as working-platforms. The counter, revolution-indicators, clock, gauges, telegraph-dials, and other engine-room fittings will be so placed near the working-platforms as to be in full view while working the engines. Speaking-tube mouthpieces and telegraph-levers will be conveniently placed.

WORKING-LEVERS AND GEAR.

There will be at each working-platform the following hand-gear, viz:

One reversing-lever;
Four starting-valve levers;
Four cylinder drain-cock levers;
Hand-reversing pump-lever;
Throttle-valve hand-wheel;
Steam throttle-valve lever;
Bleeder-valve hand-wheel;
Reversing-engine stop-valve hand-wheel;
Starting stop-valve hand-wheel.

All levers will have spring-latches of "locomotive pattern". The latches on reversing levers will be of May's pattern or equivalent.

SHAFTS.

All the crank, thrust, and propeller-shafts will be of steel. Each length will be forged solid in one piece, and will have a hole drilled axially through it from end to end.

All shafts will be finished all over.

CRANK-SHAFTS.

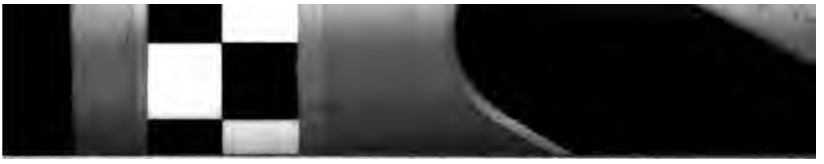
There will be three sections of crank-shafts for each propelling-engine, the two forward sections being interchangeable and the after section reversible. Each of the forward sections will have a crank of 16½ inches throw, and the after section will have two cranks each 16½ inches throw, and placed at an angle of 180°.

Each crank-shaft will have a coupling-disc, 3 inches thick and 25¼ inches diameter, forged on each end.

The length of each short section of shaft will be 7 feet 5½ inches over all, and of each long section 14 feet 3 inches over all. There will be a journal on each side of each crank 13½ inches in diameter.

The shaft will be increased to 14 inches diameter at the eccentric seatings. The crank-pins will be 14½ inches diameter and 18 inches long. The crank-webs will each be 15½ inches wide and 8½ inches thick for the short sections, and 9 inches thick on the long sections; the webs to be chamfered, as shown in drawing. The crank-pins must be accurately parallel to the main journals. All journals are to be smoothly and accurately turned, and when finished will be tested and their accuracy proved. There will be a hole 6 inches in diameter bored axially through each shaft and crank-pin. When bolted together the cranks of the short sections will be at an angle of 180° to each other; the cranks of the short sections will make an angle of 90° with the cranks of the low-pressure cylinders.

The forward end of the hole in crank-pin will be closed by a brass plate fastened on with countersunk screws.



Two radial ½-inch holes will be drilled in each crank-pin from the outside to the bore.

The various lengths of the crank-shafts will be coupled to each other by 3-inch bolts. There will be 6 bolts in each coupling, all holes being drilled or reamed to template, so that the couplings will match indiscriminately. The bolts will be made of forged-steel, finished to fit the hole snugly, and each fitted with wrought-iron nut and split-pin.

On the coupling-disc of the crank-shafts, between the intermediate and forward low-pressure cylinder, there will be a worm-wheel for turning the shaft. The thrust-shaft will be coupled to the crank-shaft by a flexible coupling.

THRUST-SHAFTS.

They will be 13 inches in diameter, with 6½-inch axial holes. Each shaft will have thirteen thrust-collars 1⅝ inches thick, with spaces of 2⅛ inches, the collars to be 17½ inches outside diameter. There will be a coupling-disc keyed on the forward end to form part of the flexible coupling. The coupling-disc at the after end will be forged on, and the shaft will be increased in diameter for a short distance, so that the hole in the shaft can be counterbored to accommodate the nut on the central stud of the inboard propeller-shaft coupling.

PROPELLER-SHAFTS.

The propeller-shafts will each be in two lengths. A 6½-inch hole will be bored in both sections of shaft. Sixteen inches from the forward end of the forward section this hole will be tapered to a diameter of 6 inches, 13⅜ inches from end; it will be threaded and fitted with a steel stud, locked in place.

The forward section of each shaft will be about 41 feet long and 13¼ inches diameter, cased with composition ¾ inch thick at the bearings and ⅜ inch thick elsewhere. The casing will be shrunk and pinned on, and must be water-tight. The casings must be accurately and smoothly turned to form journals.

The coupling-sleeve on the forward end will be of cast-steel, 15 inches long, 27 inches outside diameter, and will be fitted and keyed by at least three feathers. It will be secured to the shaft by a wrought-iron washer 15½ inches in diameter and 2 inches thick; this washer being secured to the shaft by a central steel stud and nut to take up the backing thrust.

The stud will be fitted to the thread in the bore of the shaft and reduced to 4½ inches diameter at the washer, its nut to be fitted with a suitable keeper. Steel bolts will unite this sleeve to the after coupling of the thrust-shaft. The coupling-bolts will be fitted snugly in the sleeve for 3 inches from the face, the remainder of the bolts being turned to clear.

The after end of forward section will have a coupling-disc forged on.

The after section will be about 34 feet long and 13¼ inches diameter, cased with composition ¾ inch thick where it passes through the stern-tube up to the outboard-coupling. It will have forged on the forward end a coupling-disc.

The after end will be tapered to fit the bore of the propeller-boss, and will be fitted for two feather-keys.

Abaft this the diameter will be reduced to 9½ inches, threaded and fitted with a nut and keeper, the thread being turned off abaft the nut. There will be a water-tight plug in the after end.

The hole in this section of the shaft will be 6½ inches diameter, except in that part passing through the propeller-hub, where it will be tapered so as not to reduce the thickness of the metal around the hole.

The two lengths of each propeller-shaft will be coupled to each other by six bolts, with heads and nuts made perfectly water-tight when set up. The bolts will be fitted with nuts locked in place.

There will be at the forward end of the after section of each propeller-shaft a cast-steel casing to form a fair water-line from the end of the stern-tube to the shaft, as shown in drawings. The casing will be finished on the outside and

Each eccentric will have a long oil-cup fed by a drip-pipe, so arranged that the eccentric will be lubricated in all positions. The upper end of each eccentric-rod will carry a wiper oil-cup on each fork, these cups to take oil from wicks in cups easily adjusted to the various positions of the gear. The coupling between the after section of crank-shaft and thrust-shaft will be fitted with a centrifugal oiling apparatus with a pipe leading to each bolt-head in the thrust-shaft coupling-disc.

There will be fitted to each main steam-pipe, close to valve-chest, a Detroit or equivalent steam sight-feed oil-cup of two quarts capacity, with gauge-glass. As far as possible all the oil for the moving parts of each engine, except main bearings, will be supplied from one oil-box on the cylinder, with separate valve, sight-feed, and pipe for each part to be oiled. There will be steam sight-feed cups on each circulating, blowing, main-feed, air-pump, and bilge-pump engine. All steam sight-feed cups will have ample condensing surface on their steam-pipes. Each auxiliary engine will have a continuous automatic lubricator of approved pattern. All working parts for which oil-cups are not specified or shown in drawings will have oiling-gear of approved design, such that they can be oiled without slowing. All the oiling of each auxiliary engine will be done by one oil-box where practicable. All fixed oil-cups will have hinged covers, with stops to prevent being opened too far. Moving oil-cups, where necessary, will have removable covers. The supply of oil to various parts is to be easily regulated. All oil-cups and their fittings, except such as are cast on bearings, will be of finished cast-brass, or of sheet-brass or copper, as may be directed, with all seams brazed.

OIL-DRIPS.

All fixed bearings will have drip-cups cast on where possible, otherwise they will be of cast-brass, properly applied. All moving parts will have drip-cups or pans cast on engine-

frames where directed, otherwise to be substantially made of sheet-brass or copper, with brazed seams. All drip-cups will have drain-pipes and cocks of at least ½ inch diameter, which can be used while the engines are in operation.

JOURNAL-BOXES.

All journals or moving parts of iron or steel will run, unless otherwise specified, in composition boxes. These boxes will be lined with approved anti-friction metal where directed. All adjustable bearings will be provided with channeled-brass chipping-pieces, securely held in place and easily removable.

MANDRELS FOR WHITE-METAL BEARINGS.

Hollow cast-iron mandrels will be furnished for forming the white-metal linings of crank-pin, crank-shaft, line-shaft, and thrust-bearings. All these will be smoothly and accurately turned to size, and packed so as to be perfectly protected.

STUFFING-BOXES.

All iron boxes will be bushed with composition. All glands will be of composition and fitted with approved means of adjustment while the engines are in operation, and those not fitted with pinion-nuts and spur-rings will have lock nuts and split-pins. Metallic packing of approved kind, and equal in all respects to Watson's, will be fitted in stuffing-boxes of all piston-rods and valve-stems of main and auxiliary engines over 1¾ inches diameter. Stuffing-boxes of piston-rods and valve-stems between ¾ and 1¾ inches diameter will be fitted with metallic packing of Katzenstein's pattern, or equivalent.

BOLTS AND NUTS.

All bolt-heads and nuts less than 2 inches, except in special cases, will conform to the United States Navy standard. Screw-threads on bolts and nuts must in all cases conform to the above standard. All finished bolts, except as directed, will be kept from turning by dowels or other suitable devices.

JACKS FOR COUPLING-BOLTS.

A hydraulic jack of approved pattern will be fitted for withdrawing the bolts of the shaft-couplings.

STERN-TUBE BEARINGS.

A mild-steel tube will be riveted to the place provided for it in the extension from the ship's side.

At the lignum-vitæ bearings at each end and about the middle of this tube will be riveted two cast-steel rings of **U**-section.

The bearing-rings will be made of different internal diameters, so that the bushings may be easily inserted and withdrawn.

Each bushing will be in halves, the joint being in a horizontal plane when the bushing is in place.

The outside bushings will bear on the rings at the outside end and the middle of the stern-tube. The inside bushing will bear on the rings at the inboard end.

Sections of lignum-vitæ fitted in these bushings, put in so as to wear on end of grain, will be smoothly and accurately bored in place to suit the shaft-casing. They will be held in place in the inboard bushing by a flange at its outer end and stuffing-box flange at the inner end; and in the outward bearing of the outboard bushing by a flange at inner end and a composition ring, made in halves, secured to the bushing-flange by naval-brass cap-bolts at outward end; and at the inner bearing of the outboard-bushing by a flange at the outward end and a composition ring made in halves, secured to the bushing by naval-brass cap-bolts at inner end.

All the lignum-vitæ bearings will be well water-soaked, and bored out in place to perfect alignment and to a loose fit on the shaft-casing. The inboard-bushing will be so fitted that, after the stuffing-box is taken off, the bushing can be removed while the shaft remains in place.

STERN-TUBE STUFFING-BOXES.

At the forward end of each stern-tube there will be a composition stuffing-box, made in halves, divided longitudinally. It will be bolted to the flange on the forward end of the stern-

tube bushing. The two parts will be bolted together along the longitudinal division by proper flanges. The follower will be of composition, in two parts, with a space of 1¼ inches between the parts on each side. The packing spaces will be about 7 inches deep and 1 inch wide.

The follower-bolts will be of naval brass. To each stuffing-box, abaft the packing, a 1½-inch pipe will be attached, leading to the engine-room bilge. It will also be connected with the engine-room water-service pipes, and will be provided with valves, so that the bearing can be drained into the bilge or washed out by water from the engine-room pump at will.

STERN-BRACKET BEARINGS.

Each stern-bracket bearing will have a neatly-fitting composition lining, made in halves, divided longitudinally. When this lining is taken out the bore of the bracket must be large enough to allow the coupling-discs of the propeller-shafts to pass through it. It will have a flange by which it will be secured to the forward end of the stern-bracket. It will have a lignum-vitæ bearing about 4 feet long, fitted as in the stern-tube. The lignum-vitæ will be held in place at the after end by a flat ring bolted to the lining. A cast-steel sleeve, ½ inch thick, will be secured to each stern-bracket by six ¾-inch screws, to form a fair water-line to the propeller-boss. At the forward end of each bearing there will be a composition sleeve, ½ inch thick, secured to and supported by an extension of the lining before mentioned. This sleeve will be shaped to form a fair water-line from the shaft to the stern-bracket boss, and will be finished on the outside.

SCREW-PROPELLERS.

They will be of manganese-bronze or approved equivalent metal. The starboard propeller will be right and the port one left-handed. They will be three-bladed, about 14 feet 6 inches in diameter. Each blade will be firmly bolted to the boss by tap-bolts of naval brass, secured by lock-plates. The recesses

for the bolt-heads will be covered by composition plates held by countersunk screws, and finished to form a smooth surface fair with the boss. The details of the blades will conform to such drawings as may be hereafter furnished.

Each boss will be accurately bored to fit the taper on after end of shaft and fitted with two feather-keys. Each propeller will be held on the shaft by a nut screwed on and locked in place. The shaft-casing will enter about 1 inch into the propeller-boss and be fitted water-tight. Each boss will be finished at the after end by a composition cap bolted on water-tight. The bosses and caps will be finished all over. The blades will be cast as smoothly as possible and have any roughness removed. The flanges of the blades will be turned and faced to fit the recesses in the bosses accurately, and, after being secured in place, must have the edges made fair.

CONDENSERS.

The condensers will be cylindrical, 5 feet 8 inches internal diameter, each made in three principal sections; the middle section of composition and the others of composition or sheet-brass not over ¼ inch thick.

There will be the following openings in the middle section of each condenser, each with properly-faced flanges, viz:

One for main exhaust-pipe, 28 inches diameter;

One for auxiliary exhaust-pipe, 7½ inches diameter;

One for air and circulating-pump exhaust-pipe, 6 inches diameter;

One for air-pump suction-pipes, 9½ inches diameter;

One for salt-feed pipe, 2¼ inches diameter, with a spray in the exhaust-passage;

One for bleeder-pipe, 6 inches diameter;

One 8-inch hand-hole with a 2-inch nozzle for steam-pipe for boiling the water in condenser;

One 15-inch man-hole opposite of the main-exhaust nozzle.

Each condenser will have a bracket at each end and two at the middle to secure it to the side of the ship, and supporting brackets at same places; each of these brackets being secured

to the flanges on middle section, and the flanges at the end of the shell, the end brackets fitting snugly to tube-sheets. The supporting-brackets will be of plate-iron stiffened by angles.

The condenser-tube sheets will be made of composition, 1 inch thick, with smoothly-finished holes for the tubes, tapped and fitted with screw-glands for packing the tubes. There will be a hand-hole at the lower part of each tube-sheet. The glands will be beaded at outer ends to prevent tubes from crawling, and will be slotted to admit a tool for screwing up. Cotton-tape packing will be used. There will be 3,715 seamless-drawn brass tubes in each condenser, $\frac{5}{8}$ inch outside diameter, No. 20 B. W. G. in thickness. The tubes will be 11 feet 6 inches long between tube-sheets and will be spaced $1\frac{5}{16}$ inch between centers. The cooling surface of each condenser will be about 6,990 square feet, measured on the outside of the tubes.

The end sections of each condenser will be riveted or bolted to the middle section, and will have flanges to connect with the tube-sheets. If made of sheet metal, the longitudinal seams will be butted and have double butt-straps, single riveted. Riveted joints will be tinned and sweated before riveting, the tinning extending beyond the seams on the outside of the condenser, so that any leaks can be easily soldered. The tube-sheets will be secured to the flanges of the shell by naval-brass collar-bolts, which will also be used for fastening the circulating-water chests.

The chest for entrance and exit of circulating water will be made of composition, with a division-plate in the middle and with four man-holes. The inlet and outlet-nozzles will each be $15\frac{1}{2}$ inches in diameter of opening.

The water-chest at the other end of the condenser will be cast in dished form, as shown. It will have four man-holes. There will be three stay-bolts to connect the water-chest to the tube-sheet.

There will be four braces of rolled naval brass connecting the tube-sheets, each $\frac{3}{4}$ inch in diameter, and each passing through a stay-tube $1\frac{1}{2}$ inch external diameter and $\frac{1}{4}$ inch thick.

Baffle-plates of brass will be fitted, as shown, to direct the

steam over all the tubes. Plates will be provided for supporting the tubes and to act also as baffle-plates.

In front of the main exhaust-nozzle, above the tubes, will be a deflecting-plate, supported as shown.

A copper tank, pipe, and cock will be provided for admitting an alkaline solution into the condenser—this pipe to connect with the salt-feed spray; the tank to be of at least 10 gallons capacity and conveniently placed. A 2-inch branch from the auxiliary steam-pipe will lead to the bottom of the condenser for cleaning the tubes by boiling.

Drain-cocks will be provided, with pipes leading to the bilge.

All parts of the condensers, except as otherwise specified, will be made of composition. All bolts to be made of naval brass. All bolts for securing flanges of pipes and man-hole plates will be standing bolts, and will, wherever possible, be screwed into the condenser-plates with heads inside. The condensers must be perfectly tight all over and be so proved after being secured in place.

AIR-PUMPS.

There will be two single-acting, vertical air-pumps, driven by a two-cylinder, vertical, inverted compound engine for each propelling-engine.

The steam-cylinders will be carried by three cast-steel frames supported upon brackets on the air-pump cylinders. Each of these frames will consist of two uprights of T-section, with bolting flanges at top and bottom, connected by a web of similar section, which web forms the support for the crank-shaft bearings. These frames will also be secured to the bulkhead.

There will be one engine-cylinder over each pump-cylinder. Each pump piston-rod takes hold of a cross-tail, which is connected with the engine cross-head over it by four steel rods. At each end of the crank-shaft will be a balance-wheel.

The crank-shaft will have three bearings. The cranks will be at an angle of 135° to each other. All parts of the pumps, except where otherwise specified, will be made of composition.

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Each air-pump will have a piston working in a cylinder of 18½ inches bore. The pump-cylinders will be cast separate and bolted to a casing serving as foundation, and containing the two sets of foot-valves. The delivery-valve chambers are shown as drawing as separate castings, bolted to flanges on pump-cylinders, but may preferably be cast in one with the pump-cylinders, shortening the passage to delivery-valves. The stroke will be 16½ inches. The pump-pistons will be cast flanged, the flange being grooved for water packing, as shown. The pump piston-rods will be made of rolled phosphor-bronze or approved equivalent metal. There will be 9 foot-valves, 6 valves in each piston, and 6 delivery-valves for each pump, all 4¾ inches in diameter, made of approved metal. Each valve will be held in place by a guard and a spiral spring of phosphor-bronze or approved equivalent metal. The valves and guards must be easily removable and held firmly in place. The valve-seatings will be made separately from the pump-casings, and will be bolted in place. The foot-valve seats will be placed in inclined positions at the sides of the pumps, and the delivery-valves horizontal at the highest parts of the pump-chambers. There must be no pockets in the pump-chambers, underneath the delivery-valves, where vapor can lodge. The gratings of the valve-seats must be so arranged that the clear opening of each valve shall be at least 13.9 square inches. The bonnets will be well ribbed and provided with jack-bolts and eye-bolts. Each air-pump will have one suction-nozzle 9½ inches in diameter. A 9½-inch copper pipe will lead from the bottom of the condenser and be breeched, there being one arm for each pump-cylinder. Each of these arms will have a straightway-valve.

The engine-cylinders will be 9¼ and 17¼ inches bore respectively. The cylinders, with their valve-chests, valve-chest covers, and slide-valves, will be made of cast-iron. The high-pressure and low-pressure valve-chests of each engine will be connected by a copper pipe 3¼ inches in diameter.

The high-pressure piston and all cylinder-covers will be made of cast-iron; the low-pressure piston will be made of composition.

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The crank-shafts, piston-rods, valve-rods, and connecting-rods will be made of forged-steel. The pistons will be fitted with cast-iron packing-rings. The cross-heads will be of composition, taking hold of a bar-guide. Each cross-head will have four arms, which take hold of the rods on each cross-head.

The crank-shafts will be $3\frac{1}{2}$ inches diameter, with bearings $4\frac{1}{2}$ inches long at ends and 6 inches long for center bearing. Each crank-pin will be $3\frac{1}{2}$ inches diameter and 4 inches long. Each cylinder will have a slide-valve, worked through gear, as shown.

Each engine will take steam from a branch of the main steam-pipe, with a stop-valve having a hand-wheel at the working-platform, and will exhaust by a special pipe into the condenser, and there will also be a pipe through which it can exhaust into the low-pressure receiver.

Each air-pump, together with its condenser, must maintain a vacuum of within four inches of mercury of the atmospheric barometer with the propelling-engines at full power under forced draught.

CIRCULATING-PUMPS.

There will be a centrifugal circulating-pump for each condenser, driven by an inclosed ~~three~~-cylinder engine. Each pump must be capable of discharging 9,000 gallons of water per minute from the bilge. The pumps will be made of composition, except as otherwise specified. Each pump-casing will be made in two parts, divided in a horizontal plane, the upper part with conveniences for handling. The suction-nozzle will form a support for the pump and will be securely bolted to its seating. This nozzle will have an opening for sea-suction of not less than $15\frac{1}{2}$ inches diameter, and a $15\frac{1}{2}$-inch opening for bilge-suction. The pump-runners will be smoothly cored, finished on the outside, and perfectly balanced. The shafts will be of phosphor-bronze or approved equivalent metal. The bearings will consist of sections of lignum-vitæ on end of

grain, dovetailed into composition split-sleeves, which will be well secured against turning. The stuffing-box glands will be each in two parts. There will be an air-cock at the top of the pump-casing and a drain-cock at the bottom. The pump-casings must be made as light as possible consistent with strength, and must be smoothly cored, with easy bends wherever the direction of the flow of water is changed.

CIRCULATING-PUMP ENGINES.

They will be of the inclosed multicylinder type, of approved pattern; each of sufficient power to secure the results above specified. The engine-valves must be of either the slide or piston type.

CIRCULATING-PUMP CONNECTIONS.

Each circulating-pump will be fitted with pipes and valves to draw from the sea or engine-room bilge, and will deliver into the condenser; or direct to the outboard-delivery pipe by a pipe connecting inlet and outlet of condenser. This pipe and the inlet pipes of condenser each to have a damper-valve of approved pattern.

The injection and delivery-pipes for condenser circulation will be not less than 15½ inches internal diameter.

There will be stop-valves in the pipes leading from the sea and from the bilge to the circulating-pump in each engine compartment. These valves will be so connected by levers that when one is shut the other is open; and both will be worked by a wheel well above the floor-plates.

SEA-INJECTION VALVES.

There will be a straight-way screw main injection-valve of not less than 15½ inches diameter in each engine compartment. It will connect with the sea by a conical steel tube through the double-bottom.

There will be a strainer on each pipe at the ship's side. The hand-wheels of these valves must be easily accessible above the engine-room floor-plates.

There will be a 1½-inch steam-pipe leading from the auxiliary steam-pipe to the injection-pipe outside of injection-valve. This pipe to have a valve at each end.

BILGE-INJECTION VALVES.

They will be as specified under the head of "Bilge-Suction Pipes."

OUTBOARD-DELIVERY VALVES.

There will be in each engine compartment a main outboard-delivery valve of the same size and type as main injection-valves.

The valve in each compartment will connect with a steel pipe about ⅝ inch thick passing through the double-bottom. The hand-wheels will be accessible from the engine-room.

FEED-TANKS.

There will be a feed-tank placed as shown in the drawing. Each tank will have a capacity of about 550 gallons. It will be made of ¼-inch wrought-iron. It will be stayed internally as may be directed. Each tank will have at least 80 cubic inches of rolled-zinc plates, about ½ inch thick, suspended from the braces. The straps suspending the zinc plates and the braces where the straps come in contact will be filed bright before fitting. The parts to be then well painted on the outside, or the joints to be made water-tight in other approved manner. The upper portion of the tank will be fitted as a filter, into which the water from the air-pump will be delivered. The filter will be provided with sponges, and so arranged that the water will rise through the sponges, and that the sponges will be readily accessible. Each tank will have a man-hole with bolted cover, and will have a glass water-gauge with suitable guards, shut-off cocks, and drain-cocks.

Each tank and filter will have the following pipe-connections: A discharge-pipe from each air-pump; an overflow-pipe leading to bilge, but so arranged that any water passing down it may be seen; a suction-pipe to feed-pumps, with valve; drain-pipes from traps, as elsewhere specified; a vapor-pipe, 4¼ inches diameter, of copper, No. 16 B. W. G. The vapor-pipe will lead up the engine-room hatch and discharge above the level of the awnings, where it will have a suitable hood, or it may be led into the main escape-pipe. Each feed-pump suction will be provided with a balanced valve operated by a copper float in the feed-tank, so arranged that it will allow no air to enter the feed-pipes. All trap-discharges and drains will enter the feed-tanks well below the ordinary water-level.

FEED-TANK SUCTION-PIPES.

From the port feed-tank a suction-pipe will lead to the main and auxiliary feed-pumps on the port side, and from the starboard tank a similar pipe to the pumps on the starboard side. These pipes will be connected with each other in the engine-rooms with valves, so that either feed-pump can draw from either or both tanks. Non-return valves will be fitted in these pipes close to auxiliary feed-pumps.

SUCTION-PIPES FROM BOTTOMS OF CONDENSERS.

From each air-pump channel-way below the foot-valves a 2-inch pipe will lead to the corresponding feed-tank suction-pipe, with a screw-down non-return valve.

SEA-SUCTION PIPES.

A pipe will lead from the sea-suction valve in each engine-room to the fire and bilge-pump, the auxiliary-pump, the auxiliary feed-pump, and the circulating-pump for auxiliary condenser in its compartment. A pipe will also lead from a special sea-valve, fitted where directed, to the distiller circulat-

[redacted]

bilge —

ing-pump. Each of these pipes will be of at least the same bore as the nozzle on the pump with which it connects. Each sea-suction will be controlled by a valve which will not permit sea-water to enter any of the bilge-suction pipes or feed-tank suction-pipes.

BILGE-SUCTION PIPES.

There will be the following suction-pipes from the bilge and from the drainage-pipes to the various pumps:

A 15½-inch copper pipe will lead inboard from each circulating-pump, with a valve close to the pump, as before specified. A 12-inch branch from each of these pipes will lead into the drainage-cistern on its side of the fore-and-aft bulkhead, with a screw-down non-return valve which can be lifted from its seat by means of its stem. Each pipe will also have a 12-inch branch direct to the bilge in its own compartment, with a non-return valve which can be lifted from its seat by means of a sliding-stem, but without means of fastening it shut except by lashing the lever by which its stem is worked.

The ~~above-mentioned~~ suction-pipes will ~~not~~ have strainers.

A 3-inch pipe will lead from the lowest part of the bilge of the compartment abaft the engine-rooms to both of the fire and bilge-pumps. A pipe of the full size of fire and bilge-pump suction will lead out of each drainage-cistern to the pump on its side of the fore-and-aft bulkhead. The pipes here specified, which supply each fire and bilge-pump, will lead to a valve-box near the pump, which will contain a screw-down non-return valve for each suction. Between this valve-box and the pump there will be a Macomb, or equivalent, bilge-strainer. There will be no other strainer or valves in any of these pipes other than those herein specified.

Each auxiliary feed-pump will have a suction-pipe of the full size of its suction-nozzle, connecting with the drainage-system and bilge, as may be directed. Each of the small feed-pumps in the forward fire-rooms will have suction-pipes leading to the main air-ducts on its side of the fore-and-aft bulk-

head, and to the bilge as may be directed. The suctions to each pump will lead to a valve-box and strainer fitted as before specified for the suctions to the fire and bilge-pumps.

The lower ends of all bilge-suction pipes will be of galvanized-iron. Care will be taken that all the copper bilge-pipes are led sufficiently high to keep them out of the bilge-water under ordinary circumstances.

FIRE AND BILGE-PUMPS.

There will be in each engine-room a pump of approved design, which will be used as a fire and bilge-pump. It will have a capacity of 300 gallons per minute, with steam cylinder of suitable size to work as a fire-pump with steam of 60 lbs. pressure. Each of these pumps will have suctions from the sea, the bilge as may be directed, and the drainage-system; and will deliver into the fire-main and overboard.

ENGINE-ROOM AUXILIARY PUMPS.

There will be in each engine-room an auxiliary pump of approved pattern, of 150 gallons capacity per minute, and with cylinders of proper proportion, to be used as a fire-pump with steam of 60 lbs. pressure. This pump will have suction from the sea only, and will deliver into the engine-room water-service pipes and the fire-main only.

ENGINE-ROOM WATER SERVICE.

There will be in each engine-room a 3-inch pipe connected with a special sea-valve and with a special auxiliary-pump delivery, with branches leading to the different parts of the engine, as follows:

A $1\frac{1}{2}$-inch branch connected by a union-joint with a pipe screwed into the cap of each crank-shaft bearing, and leading through brasses to top of journal;

Two $1\frac{1}{2}$-inch pipes to each crank-pin;

Two 1-inch pipes to each cross-head;

One $1\frac{1}{4}$-inch pipe to each cross-head guide;

One 1-inch pipe to each pair of eccentrics;
One 2-inch pipe to each thrust-bearing;
One 1-inch pipe to each line-shaft bearing;
Two 1-inch pipes to each air-pump engine and to each circulating-pump engine.

All of the above to have detachable sprays or short lengths of hose, as directed, and where directed to have pivoted nozzles.

Each branch will have a separate valve.

All the water-service pipes and fittings above the floors will be of polished brass. The pipes in the two engine-rooms will be connected with each other by a 2-inch pipe and valve.

TURNING-ENGINES AND GEAR.

There will be in each engine-room a double engine of suitable size for turning the main engines with steam of 60 lbs. pressure. This engine will drive by worm-gearing a second worm, which may be made at will to mesh with a worm-wheel on the propelling-shaft. The worm-wheel of each engine will be fitted on the flange-coupling between the intermediate and forward low-pressure cylinders.

The turning-engine shaft will be squared at the end and fitted with a ratchet-wrench, of approved design, for turning by hand.

Each turning-engine will have piston-valves, and will be made reversible by means of a change-valve moved by a screw and hand-wheel.

The turning-wheels will be of cast-steel with cut teeth.

SECURING ENGINES IN VESSEL.

The engines will be adjusted and aligned upon the engine-keelsons, and when accurately in line snugly-fitting wrought-iron washers will be fitted around all holding-down bolts. The holding-down bolts will be firmly set up and bolts and nuts locked in place.

When finally secured all shafting must be accurately in line with the vessel at load-draught and ordinary stowage.

All parts of the machinery and boilers will be secured in an approved manner, to prevent displacement when the vessel is used for ramming.

with seamless tubes

STEAM AND VACUUM-GAUGES.

There will be the following gauges, in polished brass cases, suitably engraved to show to what they are connected; all to be of approved pattern and equal to "Lane's improved":

Two on each boiler;

One connected to each main steam-pipe;

One connected to each intermediate valve-chest;

One connected to each low-pressure valve-chest;

One connected to each condenser.

All the above will have 8½-inch dials; those in engine-room to be at the working-platform.

Also the following with 4½-inch dials:

One connected to each intermediate cylinder-jacket;

One connected to each low-pressure cylinder-jacket;

One on auxiliary steam-pipe in each engine-room and each fire-room;

One on each circuit of radiator-pipes.

The gauges on valve-chests and steam-jackets will be plainly marked with the limit of pressure permissible. The gauges on intermediate and low-pressure valve-chests will indicate both pressure and vacuum.

A mercurial vacuum-gauge will be connected to each condenser.

THERMOMETERS.

There will be the following thermometers—all to be permanent fixtures, with their stems and bulbs protected by brass covers; the casings and fittings to be of polished brass:

One on each hot-well;

One on each feed-tank;

One on each main feed-pipe in fire-rooms;

One on each main injection-pipe;

One on each main outboard-delivery pipe;

One on each main steam-pipe close to engine.

The hot-well and feed thermometers will be so fitted as to waste no feed-water.

There will also be furnished:

Four spare water-thermometers complete;

Six spare steam-thermometers complete;

Two standardized thermometers, graduated on stem and reading to $\frac{1}{10}$ degree Fahrenheit; stems to be at least 20 inches long; each thermometer to be in a rubber-lined brass case, and each case to be suspended by springs in a suitable permanent locked case in engine-room. These thermometers must be equal to those made by H. J. Green, and be accompanied by certificates of standardization.

REVOLUTION-INDICATORS.

They will be of such approved pattern as shall not be affected to a perceptible degree by the motion of the ship or by changes of temperature. They must be worked off the engines by positive motions, and must be so fitted that changes of engine speed shall not produce violent fluctuations of the indices. There will be two in each engine-room, one to show the speed of each propeller.

REVOLUTION-COUNTERS.

They will be of the continuous rotary type, to register from 1 to 1,000,000, each worked by positive motion; each to be in a polished brass case. There will be fitted:

One for each main engine;

One for each main air-pump;

One for each main circulating-pump.

Tell-tales will be fitted on the bridge and in the conning-tower, to show the direction of revolution of the main engines.

ENGINE-ROOM TELEGRAPHS.

A repeating-telegraph of approved pattern will be fitted in each engine-room with its dial at the working-platform, and connected to transmitters in conning-tower, in wheel-house, and on bridge. The connections are to be made in such manner that the chance of derangement shall be minimized.

SPEAKING-TUBES.

They will be made of copper not less than No. 20 B. W. G. They will connect each engine-room with each fire-room; the engine-rooms with each other; the fire-rooms with each other; each engine-room to the pilot-house, conning-tower, bridge, and to the chief engineer's room; each fire-room with the upper deck close to the top of the ash-hoist, and elsewhere as required. Each tube will be fitted at each end with a mouth-piece and approved annunciator; the mouth-pieces to be connected to short flexible pipes where required. All mouth-pieces or pipes will be plainly marked. The tubes will be suitably cased where necessary.

ENGINE-INDICATORS.

An indicator connection will be made to each end of each cylinder of main engines, and to each end of each steam and water-cylinder of each air-pump, as near as possible to the bore of the cylinder, and so as to be easily accessible. Each indicator on cylinders of main engines, when in place, will be connected to but one end of a cylinder. The connecting-pipes will be 1-inch bore, without bends. The indicator-motion of each engine and air-pump will be so fitted that both indicators on its cylinder can be connected at the same time. The motions of the indicator-barrels must be accurately coincident with the motion of the corresponding pistons, and such as to give a motion of not less than 4 inches. The steam-cylinders of all auxiliary engines will have holes tapped for indicator-fittings, and then plugged. These engines will have portable indicator-motions fitted, then removed and suitably marked and stowed. Where auxiliary engines are duplicated but one set of indicator-motion fittings need be supplied for all of each kind.

Ten indicators will be furnished for each engine-room: two for the high-pressure cylinder; two for the intermediate-pressure cylinder; two for each low-pressure cylinder, and two indicators for auxiliary engines. Each indicator will have two springs of approved scales.

The indicators will be of approved type, with detent-motion and with adjustable tension to the barrel-spring. They will be nickel-plated, and will be complete with all attachments. One extra cock-attachment will be furnished with each indicator. Each indicator will be in a separate locked case; each case to be suitably marked on a brass plate, and each case to be conveniently stowed.

ENGINE-ROOM DESKS.

A black-walnut desk of approved pattern, with locked drawers, and with a locked cabinet of pigeon-holes, will be fitted in each engine-room where directed.

CLOCKS.

There will be in each engine-room, close to the counter, an eight-day clock of approved pattern, with second-hand, in a polished brass case, with 8½-inch dial.

There will be in each fire-room a similar clock, with an outer dust-tight case with heavy plate-glass.

VENTILATING-FANS.

An exhausting fan with a capacity of at least 10,000 cubic feet of air per minute will be fitted in each engine-room. Air-ducts will be led to these fans with adjustable openings so arranged as to thoroughly ventilate the engine-rooms and shaft-alleys; the air to be discharged through ducts leading up the engine-room hatch with outlets so arranged that the foul air will not be drawn back down the hatch.

Each fan will be driven by an independent engine of the same kind as specified for the fire-room blowers.

BOILERS.

There will be four double-ended boilers and two single-ended boilers, to be used as auxiliaries. Two of the main boilers will be about 13 feet 4 inches outside diameter and 20 feet 3½ inches long, the other two main boilers will be about 14 feet 6½ inches outside diameter and 20 feet 3½ inches long.

The two auxiliary boilers will be about 11 feet 2 inches outside diameter and 9 feet ½ inch long.

The total grate-surface will be about 597 square feet, and the total heating-surface about 19,382 square feet.

The boilers will occupy four water-tight compartments, as shown.

BOILER MATERIAL.

All plates used in the construction of the boilers will be open-hearth steel. The rivets will be of open-hearth or Clapp-Griffith's steel. The tubes will be of steel equal to that used by the Tyler Tube Co. All material will be tested as elsewhere specified.

BOILER-SHELLS.

~~They will be made of $1\frac{5}{32}$-inch plates—the shell of each boiler to be made in two rings, each ring of three plates.~~

The boilers of about 14 feet 6½ inches outside diameter will have a shell $1\frac{5}{64}$ inches thick; those of about 13 feet 4 inches outside diameter, a shell $1\frac{5}{32}$ inches thick; and the auxiliary boilers a shell $\frac{5}{64}$ inches thick.

The main-boiler shells will be in three courses, each course of three plates. The auxiliary-boiler shells will be in one course of two plates.

BOILER-HEADS.

Each head of each boiler will be made of three plates in the main and two plates in the auxiliary boiler. The upper plate of each head of the 14-foot 6½-inch boilers will be $1\frac{1}{8}$ inch thick, of the 13-foot 4-inch boilers will be $1\frac{1}{16}$ inches thick, and of the auxiliary boilers will be $\frac{7}{8}$ inch thick. All the other plates in heads of boilers will be $\frac{3}{4}$ inch thick, except the back heads of auxiliary boilers, which will be $\frac{11}{16}$ inch thick, and the tube sheets of the main boilers, which will be $\frac{7}{8}$ inch thick. The heads will be flanged inwardly at circumference and furnaces. The upper plate of each head will be curved back, as shown, to meet the shell of boiler. The heads will be stiffened by vertical T-bars, as shown in drawings.

BOILER-TUBE SHEETS.

They will be $\frac{3}{4}$ inch thick, except in the fronts of main boilers which will be $\frac{7}{8}$ inch thick. Each pair of tube-sheets must be accurately parallel. All tube-holes will be slightly rounded at the edges. The holes for stay-tubes will be tapped in place. The holes at combustion-chamber end will be drilled to suit the protection of tubes, as specified below.

BOILER-TUBES.

They will be of steel, lap-welded and drawn, equal in all respects to Tyler's. There will be 232 stay-tubes and 708 ordinary tubes in each of the 14-foot 6½-inch boilers, 7 feet 3¼ inches long between tube-sheets. All tubes will be 2¼ inches external diameter. Each of the 13-foot 4-inch boilers will have 192 stay-tubes and 576 ordinary tubes, 7 feet 3¼ inches long between tube-sheets. Each of the auxiliary boilers will have 66 stay-tubes and 192 ordinary tubes, 5 feet 8½ inches long between tube-sheets. The ordinary tubes will be No. 14 B. W. G. in thickness, and will be swelled to $2\frac{5}{16}$ inches external diameter at the front ends. The back ends will be expanded into recesses in the tube-sheet, or will be protected from the action of the flame in other approved manner. No method must be used which will reduce the calorimeter. The method of protection must be such as will not interfere with the use of ferrules, and will not cause injury to the tube-sheet when tubes are cut out.

The stay-tubes will be No. 6 B. W. G. in thickness. They will be reinforced at both ends to an external diameter of 2⅜ inches, leaving the bore of the tube uniform from end to end. They will then be swelled at the front end to 2½ inches external diameter. They will be threaded parallel at combustion-chamber ends, and taper at front ends to fit threads in tube-sheets. They will be screwed into the tube-sheets to a tight joint at the front end, and will be made tight at the back ends by expanding and beading. All expanding will be done by approved tools. Cast-iron ferrules of 1½ inches in-

ternal diameter will be used to protect the ends of stay-tubes in combustion-chambers. All tubes will be spaced $3\frac{1}{4}$ inches from center to center vertically and $3\frac{1}{2}$ inches horizontally.

COMBUSTION-CHAMBERS.

There will be six combustion-chambers in each main boiler and two in each auxiliary boiler, one for each furnace. They will be made of $\frac{1}{2}$-inch plates, except the tube-sheets, which will be as before specified. The backs of the combustion-chambers will be rounded at the top in the main boilers, and the top will be flat and braced by girders and bolts in the auxiliary boilers, as shown in the drawing. The plates will be flanged where necessary, and all parts joined by single-riveting. The holes for screw stay-bolts in plates of combustion-chambers and shells will be drilled and tapped together in place.

BOILER BRACING.

The bracing of each boiler will be as shown in drawings.

The combustion-chambers will be stayed to each other and to the shell of the boiler by screw-stays, spaced 7 inches horizontally and vertically, screwed into both sheets and fitted with nuts—the nuts to be set up on beveled washers where stays do not come square with the plates. The screw-stays will be $1\frac{3}{16}$ inches diameter except those nearest the sides of the combustion-chambers of single-ended boilers, which will be $1\frac{5}{16}$ inches diameter. The holes for screw-stays will be tapped in both sheets in place.

The tops of the combustion-chambers will be braced as shown in drawings.

The bottoms of the combustion-chambers will be stiffened by angles.

All screw-stays and all screwed braces will have raised threads.

All braces will be made without welds.

RIVETED JOINTS.

The longitudinal joints of boiler-shells will be butted, with straps inside and outside, and treble-riveted, as shown. The joints of heads with shells will be double-riveted; all other circumferential joints will be lapped and treble-riveted. Joints in furnaces and combustion-chambers will be single-riveted. Rivets will be of steel. Edges of all plates in cylindrical shells, and of all flat plates where not flanged, will be planed. Edges of flanges will be faired by chipping or otherwise, as may be approved. Plates in cylindrical shells must not be sheared nearer the finished edge than a distance equal to one-half the thickness of the plate along the circumferential seams, and not nearer than one thickness along the longitudinal seams. No plate must average less than the specified thickness along the longitudinal seams. All rivet-holes in shell-plates will be drilled in place after bending. Hydraulic riveting will be used wherever possible. In parts where hydraulic riveting cannot be used, the rivet-holes will be coned and conical rivets used. Seams will be calked on both sides in an approved manner. Longitudinal seams will break joints. All joints will be as shown on drawings.

BOILER MAN-HOLES AND HAND-HOLES.

There will be man-holes and hand-holes as shown in drawings. Each of these man-holes will have a stiffening-ring riveted on the outside of the boiler-head. The plates will be of cast-steel in dished form, each plate secured by two wrought-iron dogs and two $1\frac{1}{4}$-inch studs with square nuts. Each plate will have a convenient handle.

Each of the man-holes in the top plate of heads will have a raised cast-steel ring riveted to the shell of boiler.

The hand-hole plates will be cast-steel, and will be secured by dogs and bolts.

All plates, dogs, and nuts will be indelibly marked to show to what holes they belong.

FURNACES.

Each furnace will be in one piece and corrugated. The thickness and diameter will be as shown in drawings. They must be perfectly circular in cross-section at all points. They will be riveted to flanges of front heads and will be flanged and riveted to combustion-chamber plates. The corrugations of adjacent furnaces will be made to alternate.

GRATE-BARS AND BEARERS.

The grate-bars will be of wrought-iron, of approved revolving or shaking pattern. They will be so fitted that they can be readily worked under forced draft without opening the furnace or ash-pit doors, and without allowing an escape of air or gases. They will also be so fitted as to be readily removed and replaced without hauling fires. The bars at sides of furnaces will be made of cast-iron to fit the corrugations.

The bearers will be made of wrought-iron, supported by wrought-iron lugs bolted to the furnace-flues.

BRIDGE-WALLS.

They will be made of cast-iron, so fitted as to be readily removable. They will extend back to the back of combustion-chambers so as to leave no place behind them where dirt can accumulate. They will be finished with fire-brick or other approved refractory material.

FURNACE-FRONTS.

They will be made with double walls of wrought-iron, bolted to a light frame. The space between the two walls will be in communication with the ash-pits, with the space between the inner and outer plates of the furnace-doors. Dampers will be fitted to regulate the amount of air admitted to this space. The upper part of the inner plate of furnace-front will be perforated as directed. The dead-plates will be made of cast-iron, and fitted so as to be easily removable. The door-openings will be as large as practicable. There will be a beading on the inside of the door-frame in wake of the inner plate of door to make the clearance as small as possible.

FURNACE-DOORS.

They will be made with inner and outer walls of wrought-iron secured together with socket-bolts. The outer plates will be flanged back and made a tight joint against the furnace-fronts. The inner plate will have as little clearance as possible when closed. It will be perforated as may be directed. The space between the inner and outer walls will be in free communication with the ash-pit, through the furnace-front, so as to prevent gases leaking out around the door. There will be three hinges to each door, all of wrought-iron. The upper hinge will be so made as to support the weight of the free end of the door, and so fitted that the sag can be easily taken up. The latches will be of wrought-iron.

AIR-DUCTS.

From each of the fire-room blowing-fans a wrought-iron trunk will lead vertically down to the space underneath the fire-room floor-plates, which will be bolted down to form an air-tight duct. Or, if preferred, a separate duct may be built under the floors, leaving the floor-plates loose. The wrought-iron sides of ducts will be not less than $\frac{3}{16}$ inch thick. Plates will be removable where necessary to get at boilers for repairs. From the main air-duct branches will lead to all ash-pits, each fitted with a door in front of ash-pit and each fitted with a damper. These dampers will be so fitted as to be easily removable for repairs, and will each be provided with a lever and catch for opening and closing; to be so fitted that the amount of opening can be quickly and easily graduated.

The dampers must be made to work easily, and when closed must be practically air-tight. The air-ducts will be so arranged that the lower man-holes will be easily accessible. If necessary to make parts of the ducts removable for this purpose, the removable sections will be fitted with handles and with beckets for hanging them on hooks provided for the purpose.

The air-ducts below the floors must be water-tight, and so proved. All air-ducts will be tested for air-tightness under the pressure needed to produce the requisite combustion.

Man-holes will be arranged in main air-ducts where directed, with suitable covers. The covers of man-holes in fire-room floor-plates will be sufficiently heavy to be kept down by their own weight, and will rest upon suitable packing. A suction will lead from the lowest part of each main air-duct to the small feed-pump in the forward fire-room, on its side of the fore-and-aft bulkhead.

ASH-PIT DOORS.

They will be made of $\frac{1}{8}$-inch wrought-iron, stiffened with angle or channel-iron. They will be fitted with asbestos or other approved material to make an air-tight joint where fastened to air-ducts; this packing material to be so fitted as to be protected from injury, and so as to be readily renewed. Each door will be fastened in place by wrought-iron buttons bolted to lugs on the walls of the air-duct, each button setting up on a wedge riveted to the door. Each door will have two wrought-iron handles, two wrought-iron beckets to fit hooks on uptake-doors, and an eye for slinging by.

LAZY-BARS.

A lazy-bar with the necessary lugs will be fitted in the front of each ash-pit. Also portable lazy-bars for the furnaces.

ASH-PANS.

Ash-pans of $\frac{1}{4}$-inch wrought-iron, reaching from the front of furnace-flue to bridge-wall, will be fitted to all furnaces.

CIRCULATING-PLATES.

Each boiler will have circulating-plates fitted at each side of each nest of tubes. They will be of steel, $\frac{1}{8}$ inch thick, in sections, so as to be easily entered into and taken out of boilers, and will be secured in an approved manner. Each section will have two clips at upper and one at lower end for supporting it from the stay-tubes. The plates will be well painted all over with two coats of approved paint or cement.

UPTAKES.

They will be made of wrought-iron, No. 8 B. W. G., built on channel-iron and stiffened with angle-irons, and will be bolted to boiler-heads and shells. They will be bolted to the lower plates of smoke-pipe with slotted holes to allow for expansion.

Outside of the uptakes will be a jacket inclosing a 3-inch air-space; this jacket will be made of No. 12 B. W. G. iron, and will extend from the tops of uptake-doors to the tops of the uptakes.

The space between the plates of the uptake will be filled with an approved incombustible non-conducting material.

UPTAKE-DOORS.

The uptake-doors will be made of double shells of iron of the same thickness as uptakes. The space between the shells will be filled with the same non-conducting material as in uptakes.

The hinges and latches will be made of cast-steel or wrought-iron. Each door will have two hooks for hanging the ash-pit doors and a hook for a rope for hoisting the same.

Each door will also have an eye near its top for handling.

SMOKE-PIPES.

There will be two smoke-pipes, about 60 feet in height above the grates of the lower furnaces. The area of each smoke-pipe will be about 38½ square feet. The lower parts of the pipes will be shaped to connect with the uptakes, and will be built of No. 7 B. W. G. iron or steel. The upper parts will be built of No. 9 B. W. G. iron or steel. The pipes will be well stiffened by angles.

Each pipe will be finished at the top by an angle-iron to which the stay-shackles will be secured, and by a hood covering the casing, to which will be secured shackles for slinging painters. Each pipe will be strongly stayed by guys and turn-buckles of approved dimensions and pattern. All joints will

be butted and strapped. The pipes will be supported in an approved manner, so that their weight will not come on the uptakes.

From its junction with the uptakes to about 6 inches below the hood at top each smoke-pipe will be surrounded by a casing leaving an annular space of 3 inches. The casing will be made of iron, No. 12 B. W. G., and strengthened by angle-irons. It will be butted and strapped, flush-riveted on the outside and open top and bottom. It will be stayed to the pipe and will be finished with a half-round iron at top. There will be doors through this casing and through smoke-pipe about on a level with the main deck.

Above the smoke-pipe hatch an iron casing, No. 12 B. W. G., leaving an annular space of about 6 inches, will extend for about 5 feet, and will be finished by half-round iron. About 1 foot above this there will be a hood carried by the smoke-pipe casing.

There will be a ladder on the outside of each pipe, on the forward side, reaching to the top; these ladders to be made of round iron, bent and riveted to the pipes.

SMOKE-PIPE COVERS.

Each smoke-pipe will have a permanently-fixed cover made of wrought-iron, No. 11 B. W. G., built on angles in a slightly dished form and supported by angles riveted to the smoke-pipe. The cover will be placed about 33 inches above the top of the smoke-pipe so that it will not interfere with the exit of the gases, and will overlap the smoke-pipe about 18 inches all around.

BOILER-SADDLES.

Each main boiler will rest in four saddles, and each auxiliary-boiler will rest in two saddles. Angle-irons will be riveted to the boilers to fit the saddles. They will be bolted to the saddles with allowance for expansion.

BOILER ATTACHMENTS.

Each main boiler will have the following attachments, viz:
One steam stop-valve;
One dry-pipe;
One main feed check-valve with internal pipe;
One auxiliary feed check-valve with internal pipe;
One bottom-blow valve with internal pipe;
Two safety-valves with dry-pipe;
Two steam-gauges;
Two glass water-gauges, of automatic-closing type;
Four gauge-cocks;
One sentinel-valve;
One salinometer-pot;
One drain-cock;
One air-cock;
One approved circulating apparatus;
One cock with thread for the attachment of a syringe.

All external fittings will be of composition unless otherwise directed. All fittings will be flanged and through-bolted or attached in other approved manner. All cocks, valves, and pipes will have spigots or nipples passing through the boiler-plates. All internal pipes will be of brass, No. 14 B. W. G., and must touch the plates nowhere except where they connect with their external fittings. The internal feed and blow-pipes will be expanded in the holes in boiler-shells to fit the nipples on their valves, and they will be supported where necessary in an approved manner. The stems of all valves on boilers are to have outside screw-threads. The internal feed and blow-pipes are to be arranged to come between the corrugations of furnaces.

BOILER STOP-VALVES.

There will be a 9½-inch self-closing stop-valve, with horizontal spindle, on each main boiler. Each auxiliary boiler will have a 5-inch self-closing stop-valve. The valve will be bolted to the front head of each boiler, as shown, there being a spigot beyond the flange long enough to afford a good fastening for the dry-pipe.

DRY-PIPES.

There will be in each main boiler, as high as possible and properly supported, a $9\frac{1}{2}$-inch tinned-copper dry-pipe, No. 14 B. W. G., extending nearly the length of the boiler, perforated on its upper side with longitudinal slits, as shown. The auxiliary boilers will have 5-inch dry-pipes, similar to main-boiler dry-pipes. The valve end of the pipes will be expanded so as to fit the spigots of the stop-valve nozzles, and will be secured to them by four pins. The pipe will be closed at the inner end and have a $\frac{1}{2}$-inch drain-hole in its under side near each end.

FEED CHECK-VALVES.

The main and auxiliary check-valves will each be $2\frac{3}{4}$ inches in diameter. They will be fixed on the shell at front ends of the boilers, but entirely separate from each other, and will be fitted with internal pipes, the main feed-pipes leading above the tubes and pointing downward in the water-spaces between the nests of the tubes and between one of the wing-nests and shell, as shown. The auxiliary internal feed-pipe will lead downward to near the bottom of the boiler, as shown.

The valve-cases will be so made that the bottom of the outlet-nozzle shall be at least $\frac{1}{2}$ inch above the valve-seat. The valves will be assisted in closing by phosphor-bronze spiral springs. These valves will have polished brass bent bar-handles in lieu of hand-wheels.

SAFETY-VALVES.

Each main boiler will have two $4\frac{1}{2}$-inch, and each auxiliary boiler two $2\frac{1}{8}$-inch, spring safety-valves, placed as near the front of boiler as possible; the two valves to be in one case. Each valve will have a projecting lip and an adjustable ring for increasing the pressure on the valve when lifted; or an equivalent device for attaining the same result. They will be adjustable for pressure up to the test pressure; the adjusting mechanism to have an index to show the pressure at which the valve is set, and a lock to prevent tampering with the adjustment. The locks on all safety-valves will be alike. The springs will be square in cross-section, of first quality of

with seamless tubes—

BLOW-PIPES.

A 3-inch pipe will connect with all bottom blow-valves in each compartment and with a sea-valve in the same compartment. This pipe will have a nozzle for the connection of a pipe for pumping out the boilers. There will be a straight-way-valve in the blow-pipe as near the sea-valve as possible. All joints will be flange-joints.

BOILER PUMPING-OUT PIPES.

A 3-inch pipe will connect the bottom blow-pipe in each compartment with the auxiliary feed-pump, or the small feed-pump in the forward fire-room on its side of the fore-and-aft bulkhead, with a screw stop-valve above the floor near the pump.

STEAM-GAUGES.

There will be two spring steam-gauges, equal to "Lane's improved," on each boiler, with 8½-inch dials, one graduated to 185 and the other to 255 pounds. Each gauge will have an independent connection with its boiler and be fitted with a three-way cock and a coupling for attachment of a test-gauge.

BOILER WATER-GAUGES.

Each boiler will have two glass water-gauges of approved automatic-closing pattern. Each gauge will be placed at the side of the boiler and will have 1½-inch pipes leading to top and to near bottom of boiler, with a valve in each close to boiler. The shut-off and blow-out cocks are each to have at least ½ inch clear opening, and will be packed cocks, with levers and rods for working from fire-room. The glasses will be about 16 inches in exposed length, with the lowest exposed part about one inch above the highest heating surface. The glasses will be well protected. A brass index-plate, with letters and arrows cast in relief, will be fixed close to each gauge-glass to show the height of the top of combustion-chamber. The blow-out cocks will have drain-pipes leading to bilge, with union joints.

GAUGE-COCKS.

There will be four asbestos-packed gauge-cocks of approved pattern on each boiler, with rods and levers for working from fire-room. Each cock will have an independent attachment to the boiler. They will be spaced about 6 inches vertically, the lowest one being about 4 inches below the highest heating surface. Each set of cocks will have a drip-pan and a drain-pipe leading to bilge.

SALINOMETER-POTS.

There will be a salinometer-pot of approved pattern connected to each boiler. They will be placed in groups in the fire-rooms where directed.

BOILER DRAIN-COCKS.

Each boiler will have a 1-inch drain-cock of approved pattern.

BOILER AIR-COCKS.

Each main boiler will have a $\frac{1}{2}$-inch air-cock at its highest part, with a $\frac{1}{2}$-inch copper pipe leading to bilge.

CIRCULATING APPARATUS.

There will be fitted to each boiler an approved device for circulating the water in the boiler while raising steam. Each of these will be fitted where directed and have a stop-valve close to boiler. They will take steam from the auxiliary steam-pipe, with stop-valve in fire-room.

ZINC BOILER-PROTECTORS.

Each boiler will have rolled-zinc plates 12 x 6 x $\frac{1}{2}$ inch, placed as may be directed. Each plate will be bolted to a wrought-iron strap, which will be clamped to the stays. Each strap will be filed bright where in contact with zinc and stay, each stay being also filed bright at contact point. After being bolted in place the outside of the joints will be made water-tight by paint or approved cement.

MAIN FEED-PUMPS.

They will be vertical pumps, and each will have a capacity to supply all the main boilers when steaming at full power. The water-valves will be metallic, of approved kind. The pumps will be so arranged that the packing of the water-pistons can be got at from the tops of cylinders. The steam-cylinders must be of sufficient size to work the pumps at the required speed to feed the boilers under forced draft. The exhaust-cushion must be adjustable. All working parts will be of wrought-iron or steel.

Each main feed-pump will draw water from the feed-tanks only and deliver into main feed-pipe only. If the steam-valve is moved by a supplemental piston, the valve must have a positive motion near the end of the main-piston stroke to prevent piston striking cylinder-head. If a supplemental piston is used, its motion must be horizontal.

AUXILIARY FEED-PUMPS.

There will be in each engine-room a vertical pump of the same kind and same water capacity as one of the main feed-pumps. It will be connected to draw from the sea, feed-tank, bilge, or boilers at will, and to deliver either into auxiliary feed-pipe, fire-main, or overboard through a Kingston valve.

These pumps will have their steam-cylinders adapted for use as fire-pumps with steam of 60 pounds pressure.

In each fire-room there will be a hose connection on fire-main, furnished with a screw stop-valve.

FEED-PUMP PRESSURE-GAUGES.

Each main and auxiliary feed-pump will have a spring pressure-gauge registering from zero to at least 300 pounds per square inch.

ASH-HOISTS.

One ventilator in each fire-room will have vertical guide-strips of iron on the inside, and be fitted with all the necessary gear for hoisting ashes.

An ash-hoisting engine of approved design will be fitted in each fire-room hatch or such place as may be directed, of sufficient power to hoist 300 pounds from the fire-room floor to the deck in five seconds with steam of 60 pounds pressure.

It will have a reversing-gear, to be worked from the fire-room and from deck, with approved adjustable safety-gear to prevent overwinding and to stop the engine when the ash-bucket reaches the fire-room floor. It will also be fitted with an approved brake to control the drum. The ash-hoist will be fitted with the necessary sheaves, whip, and all appliances necessary for handling ash-buckets.

FIRE-ROOM BLOWERS.

There will be one blower of approved pattern in each fire-room.

These blowers must be capable of supplying to the fires continuously, with ease, sufficient air to maintain the maximum rate of combustion. They will take air from the fire-room in such manner as to thoroughly ventilate it, and deliver into the air-ducts.

The spindle-bearings must be accessible while the blowers are in motion, and will be of anti-friction metal in composition boxes, and, together with their lubricating apparatus, must be thoroughly protected from dust.

BLOWER-ENGINES.

Each blower will be driven direct by an inclosed multi-cylinder engine of an approved design, and of sufficient power to run the blower at full speed with steam of 100 pounds boiler pressure. The engine-valves must be of the slide or piston type.

All working parts must be closed in, but easily accessible for overhauling. The lubrication must be automatic and

thorough. The throttle-valve in the steam-pipe of each blowing-engine will be arranged to be worked from the fire-room floor, with suitable index to show how much it may be open. The steam-pipe for each blower will connect with auxiliary steam-pipe.

The shafts of blower-engines will be so fitted that a portable revolution-indicator can be quickly and easily applied without removing any part of the mechanism.

AIR-PRESSURE GAUGES.

An approved gauge, equal to those made by the E. P. Gleason Manufacturing Company, will be fitted in each fire-room to show the pressure in each main air-duct.

A portable gauge will also be supplied to each fire-room, with conveniences for connecting it to the furnaces, uptakes, and wherever desired to measure the air pressure.

All these gauges will indicate pressures in "inches of water".

FIRE-TOOL RACKS.

Racks will be fitted in each fire-room in convenient places for holding all necessary fire-tools.

ASH-DUMPS.

From each ash-hoist, on the upper deck, permanent overhead rails, suitably supported, will lead to the nearest ash-chutes on each side of the ship. Each of these will be fitted with a traveler of approved design, with all necessary appliances for carrying the ash-buckets. At the top of each ash-chute a dumping-hopper of approved design will be fitted, so arranged as to fold up out of the way when not in use. The ash-buckets are to be balanced dump-buckets, with all necessary gear complete. All the ash-hoisting and dumping-gear will be such that the buckets will not have to be lifted by hand.

ASH-SPRINKLERS.

A valve for wetting down ashes will be fitted in each fire-room where directed, and will be fitted with all necessary hose, couplings, and nozzles.

STEAM TUBE-CLEANERS.

A steam tube-cleaner, of approved design, will be fitted in each fire-room. Steam will be taken from the auxiliary steam-pipe. Sufficient length of steam-hose will be provided to easily reach all the tubes.

WORKSHOP MACHINERY.

There will be fitted in the engineer's workshop the following:

A double-geared engine-lathe of the best make and of approved pattern. It will be of at least 12 inches swing and 34 inches between centers. It will be fitted with gears for cutting threads from 4 to 40 to the inch, and with four-grade cone-pulleys.

An approved shaping-machine, to work by hand or power, of at least 10 inches stroke and 8 inches traverse, with vertical adjustment of table, with three-grade cone-pulleys, and with chuck. It will have all the usual adjustments of first-class machines of its size.

An approved double-geared hand and power drilling-machine, with three-grade cone-pulleys, capable of drilling 1½-inch holes, with adjustable swinging-table and of at least 18 inches swing.

The tools above specified will be fitted where directed in the engineer's workshop. Each machine will be driven from a counter-shaft with cone-pulleys to suit the machine.

An engine of approved pattern will be provided for driving the workshop machinery.

DISTILLING APPARATUS.

The distilling apparatus, placed where directed, will consist of two evaporators and two distillers, with their accessories, having a combined capacity of 5,000 gallons of potable water per 24 hours at a temperature of not more than 90° F. when the cooling water is taken in at a temperature of 60° F.

The evaporators will be made with shells of plate-steel with welded seams. The heads and flanges will be of cast-iron and the coils of copper, tinned inside and out. They will be felted and lagged, and will each be fitted with a safety-valve, steam-gauge, glass water-gauge, gauge-cocks, salinometer-pot, and blow-valve. They will take steam from the auxiliary steam-pipe, and will be fitted with automatic traps and with drain-pipes leading to the feed-tanks. The shells of the evaporators will be tested to 50 pounds to the square inch, and the coils and all parts subject to the boiler pressure to 230 pounds per square inch.

The distillers will be made with shells of sheet-brass, flanges and heads of composition, and coils of copper or brass, thoroughly tinned on both sides. The coils of each distiller will be divided into at least three parts, each with a separate inlet and outlet-valve.

A filter of approved design will be fitted to each distiller.

There will be efficient means for aerating the steam used in making distilled water.

There will be a steam-pump of approved pattern, and of a capacity of about 6 gallons per minute at ordinary speed, fitted to draw water from the filters and deliver it into the fresh-water tanks. The cylinders of the pump will be of "light service" proportions, for using steam of 60 pounds pressure. The water end of the pump will contain no copper or lead. A pipe will lead from the atmosphere, above the ship's awnings, to the suction of the pump, with a regulating-valve, so that air can be forced into the tanks with the water. In the water-suction of the pump will be fitted an approved water-meter, made without copper or lead. The discharge-

A cylindrical copper tank, of about 50 gallons capacity, will be fitted in each of the firemen's wash-rooms, and connected with the pump above specified. The tank will be supplied with a vent-pipe with a float-valve, which will close the vent when the tank is full. There will be a service-pipe from the tank, with a branch to each wash-basin, and one for filling buckets. Each of these branches will have a self-closing lever-faucet. In the service-pipe, close to the tank, will be a locked cock.

MAIN STEAM-PIPES.

A 9½-inch pipe will lead from each main stop-valve. The pipe leading from the junction of each auxiliary and the corresponding forward main boiler will be 9½ inches diameter; from the junction of this pipe with the pipe of the after main boiler, the pipe will be 12½ inches diameter. A communicating pipe, 12½ inches diameter, in the after fire-rooms, will join the starboard and port main steam-pipes.

Stop-valves will be placed as shown in drawing, straight-way valves being used where shown.

It must be possible to work the stop-valves in main steam-pipes next to the engines from the engine-rooms.

AUXILIARY STEAM-PIPES.

There will be an auxiliary steam-pipe extending on each side of the fore-and-aft bulkhead, through engine and boiler compartments, and to the windlass, steering, dynamo, and ventilating-fan engines, and to the engineer's workshop. It will connect with the auxiliary stop-valve of its auxiliary boiler, and with the main steam-pipe, as shown. Stop-valves will be placed as shown. Branches will extend to all auxiliary machinery herein specified. The pipe will be of sufficient size to supply all auxiliary machinery, including dynamos and ventilating-fans, when taking steam from abaft the separators. The auxiliary steam-pipe will be arranged, where possible, so that steam condensing in it may drain back to the separator. Where it is not possible to so arrange it, or wherever pockets necessarily occur, the pipe will be drained and trapped. All branches

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the auxiliary [illegible]

from the pipe to pumps or engines on a lower level will have the stop-valve for such machinery close to the main pipe, with a spindle for working it from below, so that when the pump or engine is standing idle there will be no opportunity for water to collect in the vertical pipe leading to it, which must be blown out before starting.

AUXILIARY EXHAUST-PIPES.

An auxiliary exhaust-pipe, of sufficient size for all auxiliary machinery herein specified and for such other steam-machinery as may be fitted in the vessel, will be fitted and connected to all auxiliary machinery herein specified. It will have nozzles for all other auxiliary machinery. It will have valves to direct the exhaust-steam into either condenser, into either low-pressure cylinder, or into the atmosphere through the escape-pipe at will. At each connection with condensers and escape-pipe the auxiliary exhaust-pipe will be fitted with two stop-valves so as to minimize the chance of an air-leak.

The connection with the escape-pipe will be made below the protective-deck. All exhaust-pipes from engines above the protective-deck leading to the condenser will be fitted with valves below the protective-deck.

BLEEDER PIPES.

A 6-inch branch from the main steam-pipe in each engine-room will lead to the condenser, with a stop-valve operated from the working-platform.

INTERMEDIATE AND LOW-PRESSURE STEAM-PIPES.

A 5-inch branch from the main steam-pipe will lead to each intermediate, and a similar pipe to each low-pressure valve-chest, each with a stop-valve.

SEPARATORS.

There will be in each main steam-pipe in the engine-room a centrifugal separator. They will be made entirely of cast-steel and sheet-steel, each fitted with a well-protected glass gauge and an approved automatic steam-trap, with drains delivering into feed-tank or overboard at will.

MAIN FEED-PUMP EXHAUST.

The exhaust-pipes from the main feed-pumps, in addition to the connection with the exhaust-main, will be so arranged that the exhaust-steam can be turned into the feed-pump suction instead of into the auxiliary exhaust-pipe—chambers with suitable nozzles for this purpose being fitted in the suction-pipes.

ESCAPE-PIPES.

There will be an 11-inch copper escape-pipe abaft each smoke-pipe, extending to top, finished and secured in an approved manner. Each pipe will have branches leading to all the safety-valves in its boiler compartments. Each of the escape-pipes will be fitted with an approved muffler.

The auxiliary exhaust-pipe will also lead into the after escape-pipe.

MAIN FEED-PIPES.

A seamless-drawn brass pipe, of the full size of the pump-discharge, will lead from each main feed-pump and discharge only into the main feed-pipe, having branches leading to the boilers. Each of these branches will have a straightway-valve, with hand-wheel in a convenient position for regulating the feed. All parts of the pipes will be above the floors, in plain view, and all joints made by flanges screwed on the pipes and bolted together.

AUXILIARY FEED-PIPES.

Similar pipes will lead from the auxiliary feed-pump to the auxiliary feed-pipe, having branches to each of the boilers. These branches will be fitted the same as those on the main feed-pipe.

FIRE-MAIN.

A pipe will extend fore and aft on the berth-deck, with an approved fire-plug of Navy standard size where directed in each compartment. This pipe will be connected with the discharges of the two engine-room fire-pumps, the two engine-

room auxiliary pumps, and the two auxiliary feed-pumps. Two branches from this main will lead up to the upper deck and be fitted with fire-plugs. A branch from the main will lead to each magazine passing-room, one to the compartment abaft the engine-rooms, and one to each compartment forward. Each of these branches will be fitted with a fire-plug, and will be so connected that all of the fire-pumps can work on it. There will be a fire-plug in an approved position in each engine-room and each fire-room. Drain-pipes will be fitted to drain all parts of the fire-main and branches. A reverse coupling will be supplied, with adapters to suit the various sizes and threads of fire-hose commonly in use, for the purpose of filling the boilers with fresh water from hose, on shore, or on boats alongside.

There will be a 1½-inch pipe leading from the auxiliary steam-pipe to each coal-bunker and hold, to be used for extinguishing fire. This pipe will have a valve in it close to auxiliary steam-pipe and another at each coal-bunker or hold bulkhead.

PIPES THROUGH WATER-TIGHT BULKHEADS AND DECKS.

They will be made water-tight by stuffing-boxes, flanges, or other approved means.

Pipes must not be led in such manner that the angles or tees of bulkheads have to be cut. Holes through wooden decks, where pipes pass through, will have brass or copper thimbles, made water-tight, extending at least three inches above decks.

PIPES THROUGH COAL-BUNKERS.

They will be protected by iron casings, made in sections, easily removable for repairs. Pipes must not be led under openings of coal-chutes.

DRAIN-PIPES AND TRAPS.

All places where condensed steam can accumulate will be provided with drain-pipes and cocks or valves of ample size, and with approved automatic traps, which will discharge into feed-tanks or condensers, or as directed. All traps will have

by-pass pipes and valves for convenience of overhauling. The glass water-gauges on all traps under pressure will be of an approved automatic-closing pattern. The lowest parts of all water-pipes and all pump-cylinders and channel-ways will have drain-cocks with pipes where required. The handles of all drain-cocks will point downward when closed.

THICKNESS OF PIPES.

The thickness of metal in the principal pipes will be as follows, by B. W. G.:

Steam-pipes above 12 inches bore	No. 3
Steam-pipes above 9 inches bore and less than 12 inches bore	No. 4
Steam-pipes above 7½ inches bore and less than 9 inches bore	No. 5
Steam-pipes above 5 inches bore and less than 7½ inches bore	No. 6
Steam-pipes above 4 inches bore and less than 5 inches bore	No. 9
Steam-pipes of and above 3 inches bore and less than 4 inches bore	No. 11
H. P. exhaust to I. P. cylinder	No. 4
I. P. exhaust to L. P. cylinders	No. 5
L. P. exhaust to condenser	Nos. 7 and 9
Circulating-pump suction and discharge-pipes	No. 7
Bilge-injection pipes	No. 11
Air-pump discharge to feed-tanks	No. 12
Feed-pump suction-pipes	No. 13
Feed-pipes	No. 4
Blow-pipes	No. 9
Auxiliary exhaust-pipes	No. 13
Escape-pipes	No. 13
Dry-pipes	No. 14
Connections to fire-main	No. 10
Galvanized wrought-iron bilge-suction pipes	No. 7

All pipes of which the thickness is not given in the above list will be made of approved thickness.

AUXILIARY ENGINE STOP-VALVES.

Each auxiliary engine will have stop-valves in both steam and exhaust-pipes as close to cylinders as possible. Exhaust stop-valves will be straightway where practicable. All pumps, except circulating-pumps, will have screw check-valves in both suction and delivery-pipes close to pump-cylinders, so arranged that they may be kept off their seats when desired.

MATERIAL AND FITTING OF PIPES.

All pipes, except the lower ends of bilge-suction pipes, will be of copper, unless otherwise specified.

The lower parts of bilge-suction pipes will be of galvanized-iron.

All feed and blow-pipes, all bilge-suction pipes except the lower parts, and all steam-pipes less than 3 inches in diameter, will be seamless-drawn. All copper pipes not seamless-drawn will be brazed. All copper pipes over 3 inches in diameter will have composition flanges riveted on and brazed; all under 3 inches will have flanges or approved composition couplings brazed on. All feed and blow-pipes will have composition flanges. All flanges will be faced and grooved, and joints made with approved material. All composition flanges below the floor-plates will be connected by bolts and nuts of naval brass. All bends in brazed copper pipes will be one gauge thicker than straight parts. All copper pipe T-pieces and fittings will be of composition, except where otherwise directed. Expansion-joints of approved pattern will be fitted where required. Slip-joints, if fitted, will have stop-bolts and flanges. All copper pipes in bilges will be well painted and covered with water-proof canvas, and must not rest in contact with any of the iron or steel work of the vessel.

PUMP-CYLINDERS.

All pump-cylinders, together with their valve-boxes and fittings, will be made of composition. Air-chambers will be fitted on the delivery sides of pumps or in the pipes, as may be directed.

The water-cylinders of all vertical pumps will be so arranged that the upper head can be removed without disturbing the framing, and the pistons will be fitted for overhauling from that end. All pumps will have either packed pistons or packed flanges.

PUMP RELIEF-VALVES.

All feed and fire-pumps will have adjustable spring relief-valves of approved design, connecting the delivery and suction passages.

SEA-VALVES.

There will be in the various compartments sea-valves, as follows:

In each engine-room a valve of sufficient size to supply water to the fire, bilge, and drainage-pump, and to the auxiliary pump and auxiliary feed-pump; also with a 3-inch nozzle for connection of the water-service pipe. This will be a screw stop-valve, and will have an independent connection to the side of the vessel. Also in each engine-room a double valve-box with a screw non-return valve for the fire and bilge-pump discharge, and a non-return valve for trap discharge. This valve-box may, if desired, be connected to the outboard nozzle of the main outboard-delivery valve. The main injection and outboard-delivery valves will be as elsewhere specified.

In the boiler-compartments there will be the necessary Kingston-valves for bottom-blows and for pump-discharges.

There will also be a sea-suction valve for the distiller circulating-pump, placed where directed.

BILGE-STRAINERS.

Each pipe leading from the bilges or from the drainage system of the vessel to the pumps, except to the circulating-pumps, will be fitted with a Macomb, or equivalent, strainer, above the floors.

ATTACHMENT OF VALVES TO HULL.

Steel strengthening-rings will be riveted to plating of hull around the openings for all sea-valves. The valve-flanges will be bolted to these rings by naval-brass studs, care being taken not to drill the holes entirely through the rings. A zinc protecting-ring will be fitted in each opening in outer skin in such a manner as to be easily renewed.

All suction-valves will have strainers over their openings on the outside of the vessel. These strainers will have $\frac{5}{8}$-inch holes with a collective area equal to twice the area of the valve openings. Strainers must be fastened to valve-casings and not to the plates of the hull. All valves below the turn of the bilge will have pipes secured to the outer skin of hull and passing through stuffing-boxes in the inner skin.

COCKS AND VALVES.

All cocks and valves and their fittings, except as otherwise specified, will be of composition. All hand-wheels will be of finished brass, except as otherwise specified, and will be at least one and one-half times as great in diameter as their valves. All cocks communicating with vacuum spaces will have bottoms of shell cast in and have packed plugs. All cocks over 1 inch in diameter will have packed plugs.

Valves of approved pattern will be supplied wherever necessary to complete the various pipe systems, whether herein specified or not. All valves will be so fitted as to be easily ground in, and be fitted, where required, with grinding-in guides and handles. No conical-faced valve will have a bearing on its seat of more than $\frac{3}{16}$ inch in width. All valve-spindles must turn right-handed to close, and have outside threads where practicable. Cocks and valves may have, where approved, in lieu of wheels or permanent handles, removable box or socket-wrenches, marked and stowed in convenient racks. All cocks and valves underneath the floor-plates will have their wheels or handles above the floor-plates, in easily accessible positions, unless otherwise directed. The sizes of valves as given in these specifications refer to the diameters of the equivalent clear openings.

LABELS ON GEAR AND INSTRUMENTS.

All cocks will have engraved brass plates to show their uses and to indicate whether open or shut. All valves except such as may be otherwise directed will have similarly engraved plates to show their uses, or have the same plainly engraved on hand-wheels.

All hand-levers or their quadrants will be similarly marked. Gear for working valves from deck will be marked as elsewhere specified.

All steam stop-valves will have indices to show to what extent they are opened.

All gauges, thermometers, counters, telegraph-dials, speaking-tube annunciators, and revolution-indicators will be suitably engraved to show to what they are connected.

All engraving will be deep and to be filled in with black cement.

CLOTHING AND LAGGING.

The main cylinders and valve-chests, after being finally secured in place in the vessel and tested, will be covered with approved incombustible non-conducting material and neatly lagged with black walnut all over, with polished brass bands and round-headed brass screws. The lagging will be made in removable sections over each cylinder, valve-chest, and man-hole cover, the sections to be of such size as to be easily handled, and all parts plainly marked. The lagging elsewhere will be so secured as to be easily removed, replaced, and repaired.

All parts of the condensers except the water-chests at ends will be clothed with approved material, put on in sections so as to be easily removed and replaced.

All steam and exhaust-pipes, the separators, and all steam-valves will be clothed in an approved manner with a satisfactory non-conducting material, covered with canvas, well painted. The main steam and exhaust-pipes in engine-room and the main separators will be also covered with black-

walnut lagging with brass bands. The canvas covering of steam-pipes will be secured to bulkheads where the pipes pass through them.

The steam-cylinders of all auxiliary engines will be clothed and lagged the same as main cylinders.

After the boilers are in place and have been tested and painted they will be covered all over, except where directed, as low as the saddles, with approved incombustible non-conducting material at least 1½ inches thick. This clothing will be covered on tops, sides, and back heads and on fronts, where required, by galvanized wrought-iron plates about No. 18 B. W. G., lapped not less than 1 inch and bolted together; also secured to boiler-plates at bottom by angle-iron, which will be held in place by ½-inch bolts tapped part way into the boiler-plates, and held off from the boiler-plates elsewhere by suitable distance-pieces.

RADIATORS.

Radiators of approved pattern will be furnished, fitted, and connected, with areas as follows:

In the ward-room lavatory and bath-room, one of 5 square feet;

In the passage abaft the ward-room, one of 8 square feet;

In the after ward-room, 15 square feet;

In the forward ward-room, 15 square feet;

In the steerage country, 20 square feet;

In the engineer's log-room, one of 5 square feet;

In the space between the forward and after passages on berth-deck, one of 20 square feet;

In the dispensary, one of 5 square feet;

In the paymaster's office, one of 5 square feet;

In the forward compartment of berth-deck, one of 20 square feet;

In the second compartment of berth-deck, two of 20 square feet each;

In the third compartment of berth-deck, three of 15 square feet each;

In the fourth compartment of berth-deck, three of 20 square feet each;

In the after cabin, one of 15 square feet;

In the forward cabin, two of 15 square feet each;

In the captain's pantry, one of 3 square feet;

In the captain's office, one of 5 square feet;

In each state-room on main-deck, one of 4 square feet.

In the navigator's office, one of 4 square feet;

In the captain's state-room, one of 6 square feet;

In the captain's bath-room, one of 4 square feet;

In the executive officer's office, one of 4 square feet;

In the engineer's and ordnance workshop, one of 10 square feet;

In the cabin passage-way, two of 15 square feet each;

In the firemen's after wash-room, one of 8 square feet;

In the firemen's forward wash-room, one of 8 square feet;

In the pilot-house, one of 10 square feet;

In the steerage, 24 square feet;

In the steerage pantry, one of 4 square feet;

In the steerage lavatory and bath-room, one of 4 square feet;

In the ward-room pantry, one of 4 square feet;

In the warrant officers' mess-room and pantry, one of 4 square feet.

The radiators in the ward-rooms, steerage, and steerage country will consist of pipes led along the bottom of the bulk-heads, covered with metallic removable grating.

Each radiator or coil of more than 10 square feet will be divided into two parts. All radiators will be fitted with Jenkins' valves, or their equivalent, with guards and removable keys for valve-stems. The end of the stems will be triangular in section.

The steam and drain-pipes will be of seamless-drawn brass, of iron-pipe size, suitably connected by composition fittings in a manner that will permit them to be easily taken down for repairs.

All union-joints will be coned or have corrugated copper washers.

All holes through decks and bulkheads will be thimbled with brass.

Steam and drain-pipes will be clothed where near woodwork, and elsewhere as required.

The steam-pipes will connect with the auxiliary steam-pipes where directed, and be fitted with adjustable reducing-valves.

The drain-pipe of each circuit will have an approved automatic steam-trap discharging into feed-tank, and elsewhere as directed.

The glass gauge on trap will be automatic-closing in case of breakage.

A steam-gauge with 4½-inch dial will be on each circuit.

Independent steam-pipes will lead from engine and fire-rooms to the principal divisions of the officers' quarters and forward parts of the ship.

WHISTLE.

An approved polished brass chime steam-whistle, with bell of about 8 inches diameter, will be placed forward of the forward smoke-pipe, well above the level of the awnings, and connected to the auxiliary steam-pipe by a pipe having a stop-valve at its lower end and a working-valve at the upper end. The pipe will have an expansion-joint at lower end. A drain-pipe with valve will be connected at the lowest point.

SIREN.

There will be a steam-siren of approved pattern and size, placed where directed, and connected similarly to the whistle.

HOSE AND HOSE-REELS.

A sufficient length of hose will be supplied for each engine-room and each fire-room, to lead to the farthest part of the adjoining coal-bunkers below the protective-deck. The hose for engine-rooms will be of the best quality rubber-lined linen, and that for fire-rooms will be the best quality four-ply rubber

All ladders will be so fitted as to be easily removable where required, and will be jointed and hinged, with necessary fastenings and gear, where they have to be moved when closing hatches. Light iron ladders will be fitted to and through one ventilator in each engine-room as means of egress when the battle-hatches are closed.

Gear will be provided for quickly opening the battle-hatches over the fire-room ladders, this gear to be worked from fire-room.

HAND-RAILS.

Hand-rails, easily removable where required, will be fitted to all ladders and platforms, around moving parts of machinery, and along bulkheads and passage-ways. The hand-rails and stanchions will be made of deoxidized bronze, or of approved equivalent metal which will not easily tarnish; and will be polished all over. The lower ends of stanchions will pass through floor-plates with nuts underneath.

GEAR FOR WORKING VALVES FROM DECK.

The safety-valves, boiler stop-valves, and engine-room stop-valves, as elsewhere specified, will have suitable gear for working them from the main deck.

The rods of the gear will be guided and supported on deck by cast composition standards, left rough and painted. Each rod will have a hand-wheel at least 3 feet above the deck. The main stop-valve hand-wheels will be 16 inches in diameter, each to be fitted with an approved lock and key; all locks and keys to be alike. The auxiliary stop-valves will be similarly fitted with 12-inch hand-wheels. The wheels will be of brass, polished, and will have their rims connected with the hubs by plain discs without holes in them. Or in lieu of hand-wheels, if directed, polished brass bar-handles will be fitted to squares on the turning-rods, and will be stowed in beckets on bulkheads. The tops of rods will be protected by brass caps. All hand-wheels will be engraved with name; or cast-brass label-plates with polished raised letters will be fixed to adjoining bulkheads.

LIFTING-GEAR.

Efficient lifting-gear, consisting of traveler-bars and pulleys, deck-beam clamps, turn-buckles, shackles, hooks, eye-bolts, and as may be directed, will be fitted wherever required for lifting parts of the machinery for overhauling and repairing.

Holes will be tapped in all the principal movable parts of machinery for this purpose.

OIL-TANKS.

Oil-tanks, of 1,000 gallons total capacity, divided as directed, will be fitted where directed, with facilities for filling from deck. They will be made of wrought-iron not less than $\frac{1}{8}$ inch thick, and will each have a glass gauge, a man-hole and cover near the top, and a locked-cock for drawing oil. In each engine-room there will be fitted two copper oil-tanks of 20 gallons each and two of 8 gallons each, and in each boiler compartment one of 5 gallons, all with lock-cocks. All oil-tanks will be fitted with drip-pans.

Each of the larger oil-tanks will have a hand-pump and pipes for filling the smaller tanks.

Two iron tallow-tanks, with hinged covers, will be fitted where directed.

VENTILATORS.

Ventilators, with cowls well above the awnings, will be fitted one to each fire-room, 24 inches internal diameter.

The ventilators will be of wrought-iron, No. 11 B. W. G., butted and single-strapped and flush-riveted. The cowls will be movable, of No. 12 B. W. G. copper, not planished, and at least 48 inches in greatest diameter. The base-rings of cowls will be of composition, finished on working parts but left unfinished on the outside. All cowls will be fitted with gear for turning them from engine and fire-rooms, the gear to be of composition except the spindles, which will be of wrought-iron. Brass hand-wheels or T-handles will be fitted to spindles in engine and fire-rooms.

~~Each of the ventilators will have vertical guide-strips of iron on the inside, and be fitted with all the necessary gear for hoisting ashes.~~

TOOLS.

The following tools will be furnished in addition to those elsewhere specified:

One set of wrenches complete for each engine and each fire-room, to be fitted for all nuts in their respective compartments, plainly marked with sizes, and fitted in iron racks of approved pattern. The wrenches for nuts of bolts less than one inch in diameter will be finished, and for all over two inches in diameter will be box-wrenches, where such can be used. Socket-wrenches will be furnished where required. Open-end wrenches will be of steel or wrought-iron, with case-hardened jaws, all others of wrought-iron or cast-steel;

One pair of taps, on rod, for each length of tube, for tapping front and back tube-sheets of boilers at one operation. This will be a duplicate of that used in originally tapping the sheets, and be so packed as to be perfectly protected from injury;

A fixed trammel for setting the main valves without removing the covers, the valve-stems to be properly marked for this purpose;

Fixed trammels or gauges for aligning crank-shafts, brass pins being let into pillow-blocks and center-marked for this purpose;

Two complete sets of fire-tools for each fire-room;

Two coal and two ash-buckets for each fire-room.

All trammels and gauges will have protecting cases. All tools will be conveniently stowed.

DUPLICATE PIECES.

The following duplicate pieces, in addition to others specified, will be furnished, fitted and ready for use, viz:

One set of valves for each pump;

One valve-seat, with guards and bolts complete, for air-pumps;

One-half set of follower-bolts and nuts for each steam-piston, and one set for each air-pump piston;

One-half set of springs for each steam-piston;

Two bottom brasses and two top brasses for crank-shaft bearings;

Two crown brasses and two butt brasses for crank-pins;

One cap and two butt-brasses for cross-head journals;

Brasses complete for two cross-heads;

One section of crank-shaft of each length, to be fitted in place, and delivered at such naval station in the United States as may be directed, to be left in store;

Three blades for each propeller, fitted to propeller-bosses. These blades will be of such pattern as may be directed after the trial of the vessel;

One complete set of brasses for each main engine valve-gear;

One complete set of brasses for each circulating-pump engine, each air-pump engine, each size feed-pump, each fire-pump, and each blowing-engine;

Four spare cup-leathers for each one fitted in hydraulic gear;

One piston-rod for each piston of each pump in fire-rooms;

One feed-check valve complete;

One bottom-blow valve complete;

One complete set of metallic packing for each stuffing-box;

A spare hose and nozzle for each steam tube-cleaner;

One-eighth of a complete set of grate-bars and bearers for all furnaces, and one pattern for each casting;

One dead-plate for each size of furnace and one pattern for same;

One ash-pit damper, with gear complete, for each size of furnace;

One ash-pit door for each size of furnace;

One hundred stay-tubes for boilers, threaded to fit threads in tube-sheets, with ends wrapped in canvas, the number of each length bearing the same ratio to 100 as that which all stay-tubes of that length bear to the whole number of stay-tubes;

One hundred ordinary boiler-tubes, swelled at one end and annealed, ready for use, the number of each length bearing the

same ratio to 100 as that which all ordinary tubes of that length bear to the whole number of ordinary tubes;

Two hundred condenser-tubes, packed in boxes;

Fifty condenser-tube glands;

One spare spring for each safety-valve and relief-valve;

One spare basket for each Macomb bilge-strainer;

One set of coils for each evaporator.

Wherever duplicate pieces are furnished for one of two or more pieces of machinery of the same size, they will be made strictly interchangeable.

All finished duplicate pieces not of brass, except as otherwise specified, will be painted with three coats of white lead and oil and well lashed in tarred canvas, with the name painted on outside. Brass pieces will be marked or stamped. All pieces will be stowed in an approved manner.

All boiler-tubes will be securely stowed in racks, or as directed.

MATERIALS AND WORKMANSHIP.

All castings must be sound and true to form, and before being painted must be well cleaned of sand and scale, and all fins and roughness removed.

No imperfect casting or unsound forging will be used if the defect affects the strength or to a marked degree its sightliness.

All nuts on rough castings will fit facings raised above the surface, except where otherwise directed. All flanges of castings will be faced, and those coupled together will have their edges made fair with each other. The faces of all circular flanges will be grooved.

All bolt-holes in permanently fixed parts will be reamed or drilled fair and true in place, and the bodies of bolts finished to fit them snugly.

All pipes beneath floor-plates will be connected by forged bolts and nuts of naval brass.

All brasses will fit loosely between collars of shafting.

All brasses or journals will be properly channeled for the distribution of oil.

Packing for stuffing-boxes will be such as may be approved.

All small pins of working parts will be well case-hardened.

All steel joint-pins of valve-gear will be hardened and ground to true cylindrical surfaces.

All materials used in the construction of the machinery will be of the best quality. The iron castings will be made of the best pig-iron, not scrap, except where otherwise directed.

Composition castings will be made of new materials. The various compositions will be by weight as follows:

For all journal-boxes and guide-gibs, where not otherwise specified—

Copper 6, tin 1, and zinc ¼ parts.

Naval brass—

Copper 62, tin 1, and zinc 37 per cent.

For composition not otherwise specified—

Copper 88, tin 10, and zinc 2 per cent.

Muntz metal will be of the best commercial quality.

Anti-friction metal will be of approved kind.

Ornamental brass fittings will be of good, uniform color.

All castings will be increased in thickness around core-holes. Core-holes will be tapped and core-plugs screwed in and locked, except where bolted covers are used, or where it may be directed that the holes be left open.

All steel forgings will be without welds and free from laminations.

All flanges, collars, and off-sets will have well-rounded fillets.

All boiler-plates, stays, and tubes will be well cleaned of mill-scale by pickling or other approved means.

All flanged parts of boilers will be annealed, after flanging, in an approved manner.

India-rubber valves will be of approved kind, of best commercial quality.

All bolts for securing the boiler attachments will, where possible, be screwed through the boiler-plates, with heads inside.

examination by the Inspector during the tests. All
ill also be tested after being secured on board. No
or covering is to be on the cylinders or condensers
the tests.

PAINTING.

a satisfactory test the boilers will be painted on the
with two coats of brown zinc and oil, and when in place
ts will be painted with one coat of black paint.
gine-work, not finished, will be primed with two coats
n zinc and oil, and when placed in position on board
el will be painted with two coats of paint of approved
The shafting, when in place, will be painted with two
red lead and oil and two coats of black paint.
moke-pipes will be thoroughly painted before and after
on board. The ventilators and cowls will be painted
v to the smoke-pipes, except the interiors of the cowls,
ill be painted vermilion.
ipes will be painted in accordance with a schedule to
fter furnished.

PRELIMINARY TESTS AND TRIALS.

will not be raised in the boilers until after the water-
oard, unless desired for drying or testing joints, for
urpose the pressure must not exceed 10 pounds per
nch.
testing, steam will be raised in the boilers whenever
, to test the connections and the workings of all parts
and auxiliary engines. All expense of such prelim-
sts will be borne by the contractor.

SUPERINTENDING ENGINEER'S OFFICE.

itable office and a suitable drafting-room, properly
d and heated, will be furnished by the contractor for
f the superintending naval engineer and his assistants.

RECORD OF WEIGHTS.

All finished machinery, boilers, and appurtenances thereto, as fitted, and all spare machinery and tools herein specified, will be weighed by the contractor in the presence of the superintending naval engineer or one of his assistants before being placed on board; and no part of the material will be placed on board without being so weighed to the satisfaction of the superintending naval engineer.

WORKING DRAWINGS.

All drawings necessary for the prosecution of the work must be prepared by and at the expense of the contractor. Those which are developments of the drawings furnished and of these specifications will be subject to the approval of the superintending naval engineer before the material is ordered or the work commenced.

In the drawings furnished, figured dimensions, where given, will be followed, and not scale dimensions, unless otherwise directed. All discrepancies discovered in drawings, or between drawings and specifications, will be referred to the Bureau of Steam Engineering.

A copy of each working drawing will be furnished to the superintending naval engineer before the work shown by the drawing is commenced. A copy of each drawing accompanying orders for steel castings or forgings will also be supplied when the work is ordered.

DRAWINGS OF COMPLETED MACHINERY.

The contractor will make and furnish to the Bureau of Steam Engineering, through the superintending naval engineer, a complete set of drawings of the boilers, machinery, and appurtenances as actually completed, including plans of the same as fitted on board the vessel. These drawings will include every piece of machinery, both in whole and in part, and will be in such detail as would enable the entire machinery to be duplicated without additional drawings. No

sheet will contain drawings of more than one part of the machinery, except those intimately connected with each other. The detail drawing of each part of machinery will be furnished within one month after the completion of the part, without waiting for its incorporation into the machine as a whole. Detail drawings will be made to a scale of not less than one and one-half inches to the foot. General plans of the machinery in place in the vessel will be made to a scale of one-quarter of an inch to the foot. Pipe plans will be made to a scale of not less than three-eighths of an inch to the foot. The pipe plans will be divided into at least two parts—one showing steam and exhaust-pipes and the other showing all other pipes. The pipe plans will be colored, in accordance with a schedule to be furnished, to indicate the purpose which the pipes are intended to serve, and accompanied by an explanatory index.

All drawings will be made on the best quality of tracing-cloth, all sheets being, as far as possible, multiples or sub-multiples of "double-elephant" size.

Detail drawings will be hatched, where in section, in accordance with a schedule to be furnished, to show the various metals employed.

CHANGES IN PLANS AND SPECIFICATIONS.

The contractor will make no changes in the plans or specifications without the approval of the Navy Department. In case it is thought advisable to make changes, the contractor will make application by letter to the Bureau of Steam Engineering, through the superintending naval engineer, stating the nature of the change, accompanied by complete plans and specifications of the proposed change; together with a statement of his estimate of the amount of increase or decrease in cost.

INSPECTION.

The work of construction of the boilers, machinery, and appurtenances shall be at all times open to inspection by officers appointed for such purpose by the Navy Department. Every

facility will be afforded such inspectors for the prosecution of their work. All handling of material necessary for purposes of inspection will be done at the expense of the contractor. All test specimens necessary for the determination of the strength of material used will be prepared and tested at the expense of the contractor. The contractor will furnish the superintending naval engineer with a weekly list of the number of men of each class employed upon the work, together with a statement of the number of hours labor in each class.

OMISSIONS.

Any part of the machinery, or any article pertaining thereto which may have been inadvertently omitted from these specifications or from the official drawings, but which is necessary for the proper completion of the vessel, is to be supplied by the contractor without extra charge.